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THESIS

COST ANALYSIS FOR AIRCRAFT SYSTEM TEST AND EVALUATION: EMPIRICAL SURVEY DATA STRUCTURING AND PARAMETRIC MODELING, VOLUME II

by

William J. Foster

and

Walter J. Moore Jr.

March 1987

Thesis Advisor: Tung X. Bui

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There is an increasing requirement from high levels within the Government that the Navy's aircraft cost estimators and analysts provide explicit estimates for the sub-elements of Aircraft System Test and Evaluation (AST&E) efforts. The data required to produce more accurate and detailed estimates represent lower levels in the Aircraft Work Breakdown Structure (WBS) than previously available. This is a two volume thesis. Volume I examines the WBS and Contractor Cost Data Reporting (CCDR) system with a description of current reporting practices and implementation shortcomings. Recommended courses of action to improve reporting requirements and thereby improve data quality and cost estimates

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Cost Analysis for Aircraft System Test and Evaluation: Empirical Survey, Data Structuring and Parametric Modeling

Volume II

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ABSTRACT

There is an increasing requirement from high levels within the Government that the Navy's aircraft cost estimators and analysts provide explicit estimates for the sub-elements of Aircraft System Test and Evaluation (AST&E) efforts. The data required to produce more accurate and detailed estimates represent lower levels in the Aircraft Work Breakdown Structure (WBS) than previously available. This is a two volume thesis. Volume I examines the WBS and Contractor Cost Data Reporting (CCDR) system with a description of current reporting practices and implementation shortcomings. Recommended courses of action to improve reporting requirements and thereby improve data quality and cost estimates are proposed. Major cost drivers for AST&E, from both the perspective of Defense Contractors and Military Flight Test Centers, are discussed. Beginning in Volume II, a relational data base system is introduced to more easily evaluate AST&E cost elements and physical/performance characteristics. A Contractor Flight Test cost estimating relationship (CER) is developed through step-wise multiple regression analysis of data gathered from Defense Contractors and Naval Air Systems Command (NAVAIR).

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I. SURVEY OF CURRENT DATA AND STRUCTURE

A. INTRODUCTION

All companies interviewed provided data in some form or another. Some data were better and more complete than others. Not all aircraft data requested were provided. Various reasons were given, including, (i) data too old and not available or would not be of use; (ii) aircraft were commercial derivatives and flight test data not applicable; or (iii) data were for internal use only. A synopsis of the data received, by company, is included below. This summary includes: the type of aircraft reported against, how much data was given, what form the data was in, and a short overview of the companies data collection methods.

B. DESCRIPTION BY CONTRACTOR

1. Boeing

Boeing's initial data include a breakdown of the B-52 and the KC-135 aircraft. Flight Test, Wind Tunnel Test, Static Test, Fatigue test, Flight hours, Wind Tunnel Occupancy Hours and other data were provided. The flight test data were time phased. In the case of the B-52, only block 1 aircraft were time phased, available from 1952 through 1958 in six-month intervals. With the KC 135 six-month interval data blocks 1 through 4 aircraft were included ranging from 1953 through 1959. For wind tunnel static and fatigue test, only data for the B-52 were provided. Flight test hours were provided by serial number, and wind tunnel occupancy hours were given for both B-52 and KC-135. Other data include the B-52 prototypes flight test and mockup hours. Other KC-135 data include other block 1 data, i.e., maintenance trainers, support equipment, static test, wind tunnel test, airframe and structure ground test, avionics ground test, other ground test, other system test, class I M/U, class II M/U, and class III M/U. Graphs were plotted in the section on wind tunnel occupancy to show the time phased usage of the wind tunnel. Additional Flight test and Wind Tunnel data on the KC-135-1, XB-52, YB-52 and YC-14 were provided.

All the data given was stored in a historical data base within the company owned and developed called Executive Information System (EIS). This system is a matrix-type structure with cost elements and programs forming the parents with many children, matched against the Work Breakdown Structure (WBS) down to the fifth level elements (see Figure 1-1). All cost data is from the official company accounting system and auditable to work in progress ledgers. Data can be retrieved per user desired reports or formats in tabular or graphic display (i.e., total manhours by cost element (CE), detailed manhours (CE/WBS),

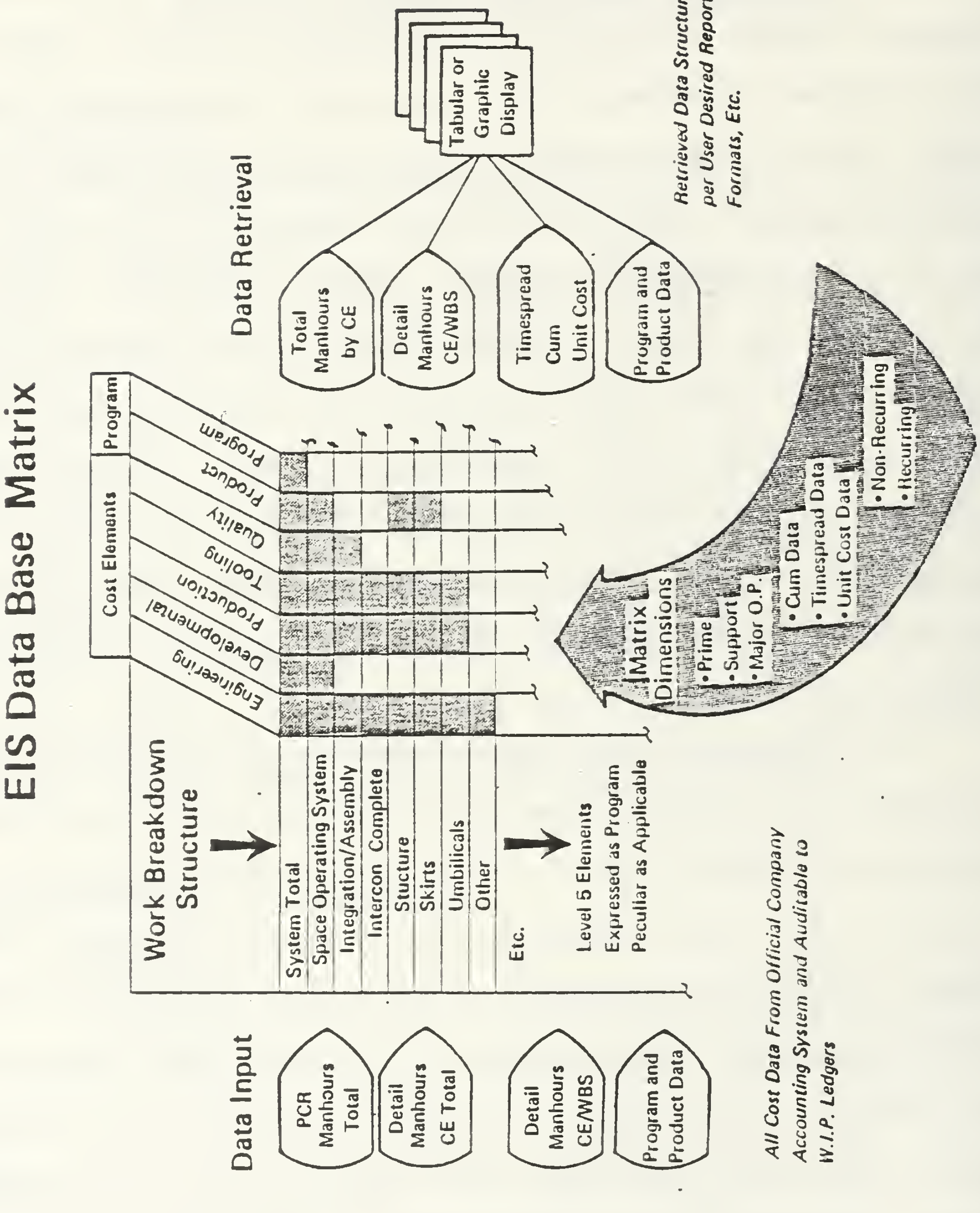


Figure 1-1. EIS Data Base Matrix

time-spread cumulative unit cost, and program and product data). Boeing also has a current on-line system to handle ongoing projects. Once these projects are completed, the information is transferred to the historical data base.

2. Rockwell International, Columbus

Rockwell Columbus provided data on the A-5A, OV-10 and the T-2. Data included total hours and dollars for Contractor Flight Test, Wind Tunnel, Static and Fatigue Test. Contractor Flight Test and Wind Tunnel were not broken down into any sub-elements; Static and Fatigue Test did not include the Engineering hours for the article test. Flight hours are time phased. Engineering and manufacturing hours are the only hours reported.

It was not understood whether or not Rockwell has an computerized data base. If they do, it is not likely real time since definitions are not standard through the company.

3. Fairchild Aircraft

Fairchild provided data on the F-105. Information was given on engineering paper and looked to be a copy of the total records kept of the aircraft. Fairchild does not have a data base. All records are apparently kept by hand. Like Rockwell, the definitions are not standard company wide.

4. Grumman Aerospace Corporation

Grumman provided data on the F-14. Initially, cost data only were provided. Later, a detailed breakdown of the system test and evaluation for Contractor Flight, Static, Wind Tunnel, and Fatigue test were offered, together with a Test to Cost Study performed by the Flight Test Department which included extensive information relating to the F-14 and other aircraft.

Grumman has a data base and a standard accounting system. Data are structured down to Level 9 of the WBS in the data base. Grumman uses the contract dictionary down to Level 5 or 6. Data below Levels 5 and 6 are defined by Grumman's Planning and Controls section. The company's definitions are standardized.

5. Rockwell International, Los Angeles

Only cost data on the B-1 were provided by Rockwell L.A.. Cumulative system test hours were made available for Static Test and Fatigue Test. These hours were broken down by unit number.

Rockwell has a computer data base accounting system. During the interview, they did not share any detail on its level of information. We were referred to the Air Force system project office for all our data requests. We were only provided dollar figures on the CCDR required reports.

6. LTV Aerospace and Defense

LTV delivered data on A-7, TA-7, XC-142A, F-8U and as a sub-contractor, S-3A and C-17. Of these, statistics on the A-7 and the TA-7 were abundant. Flight hours were time phased starting in September 1965 for the A-7 and December

1976 for the TA-7. Labor hours were divided into engineering and manufacturing, and reported for Instrumentation, Flight Test Spin Program, Night and Delivery, and Misc. For the TA-7, labor hours were not divided between engineering and manufacturing. Total hours were reported against the same items as the A-7 except for an additional item reporting category of General Flight Support.

The company's financial management department maintains the WBS to the third level. The Work Management System is a system listing by task and correlates to WBS sub-tasks. LTV does not currently have a data base that allows for retrieval of historical data by cost element. Work is in progress to implement such a data base system.

7. General Dynamics Corporation

General Dynamics provided data on the YF-16, F-111, F-16 and the B-58. Data included hours and dollars for Direct Labor Hours, Administration, Engineering, Tooling, Manufacturing, Mod and Test, Electric Fabrication Center, Q.A. and Production Support. Only dollar figures were reported for Overhead, Material and Subcontract, Material Burden, Other Direct Charges and General and Administrative Expense. In addition, a Program Overview was given along with Aircraft Characteristics, Program Unique Features, Schedule Data, and WBS Definitions.

General Dynamics maintains a company-wide MIS with matrix translation to input individual project cost data. This system captures actual cost data with dollars normalized to a midpoint for the cost period. The internal data base is used to establish cost estimation relationships.

8. McDonnell Douglas Corporation

McDonnell Douglas provided a schedule for the Static Airframe, Fatigue Airframe, and Fatigue Test Article development. They also provided a historical F/TF-15 Category I Flight Test Plan, but no data was released.

WBS accounting is kept at one level below contract requirements. If contract is at Level 3, internal records will be maintained at Level 4. Their current data base maintains information at the following levels:

- Job order--large component level
- Item level--segregates major tasks (i.e., fatigue testing)
- Cost code--sub-task of item level (i.e., forward fuselage side panel).

Cost accounting is standardized company wide in a corporate data base system used by McDonnell Douglas with each sector of the company records are maintained separately in sub-groups for specialized information.

9. Lockheed Georgia Company

Lockheed released data on the C-5, C-141 and a limited amount on the C-130. The C-5 data was broken down by Production Manhours, Engineering Manhours, Tooling Manhours, and Material Dollars. In addition, a description of the WBS used on the C-5 was provided. The C-141 data was broken down by Engineering Manhours, Tooling Manhours, and Material Dollars. A WBS description and a test and update highlights chart was provided. The limited data on the C-130 included total flight hours, number of months from 1st flight to completion of tests, and average flight hours per month.

Cost items are tracked by work order, subdivided into major class, minor class, and suffix. Suffix data has been used by different divisions of Lockheed Georgia for their own data tracking, complicating insertion of lower level cost elements into a standard company database. The work order information generally follows the work breakdown structure format. The accounting and record keeping department utilizes Boeing's information system shell to support the internal data structures. The Tops (terminal on-line pricing system) will work with the Glides (GELAC Integrated Data Bank Estimating System) system for cost estimating and analysis. As this system is fully implemented, the outer ring or system shell will be standardized company-wide. The inner ring will be tailored for departmental use. Due to differences in past job order tracking, a significant amount of time has been spent in standardizing cost data. For government contracts, they use the Sentinel system (Cost schedule control system) to track CCDR reporting requirements only. This was the basic system previously used to track work order information.

10. Lockheed California Company

Lockheed California provided data on the S-3A, this data was given in hours and dollars. Data was provided for the majority of the requested catagories. Flight hours were provided by aircraft. Engineering hours were further broken down into subcategories of the WBS.

Cost items are tracked the same as with Lockheed Georgia except that an on line data base is expected to be operational in the near future. At present, historical test data is maintained separately for each major program and not standardized company wide.

11. Naval Air Test Center

It was intentional not to gather data from the Naval Air Test Center. However, some information on an accounting system that is to be introduced in March 1987 were made available. This system is called STAFS (Standard Automated Financial System). It is not used as a real time data base and will not provide real time access to System Test and Evaluation type data.

12. Air Force Test Flight Center

The Air Force Test Center provided data on the B1-B, F-15 and the F-16. Units (hours); actual and estimated, dollars; estimated total, actual total, estimated reimbursable and actual reimbursable were reported for job order numbers. Cost-centers were broken down by JON (job order numbers), PIN (product identification number), REN (resource identification number), and EEIC (elementary element identification code).

This test center is unique in that it is a Combined Test Facility. Contractors and the test center share data collected on System Test and Evaluation aircraft. Contractors do their testing on site using the Test Centers facilities.

The Air Force Test Flight Center uses an accounting system called MISTE (Management Information System for Test and Evaluation). This system tracks and updates the test data according to the JON, PIN, REN, and EEIC numbers. It also provides the capability to create reports, standard and nonstandard.

13. NAVAIR

Additional information was provided by NAVAIR. This data was on the S-3A aircraft and came from the NAVAIR data base where the CCDR report information is held. The data was time phased in six-month intervals, standardized and reported against the WBS. This information was used as a tool to evaluate the other S-3A data.

C. SUMMARY

All data furnished can be used, however for the initial analysis, only test labor hours, as opposed to dollars, are appropriate. Therefore Rockwell's cost data will not be utilized. Also the data contributed by the Air Force Test Flight Center is not appropriate because of the inability to distinguish between Contractor Flight Test and Operational Flight Test.

Data furnished by the contractors need to be standardized and compared to the individual companies' CCDR reports held at NAVAIR before they can be used for statistical purposes. Once this task is accomplished, the data could be ready for analysis. However to facilitate the analysis process, the data should be re-arranged in a cohesive and consistent framework. This could be accomplished by developing a data base structure where data could be maintained. This would also facilitate the ease of use as well as the analysis.

II. A SURVEY OF PARAMETRIC TECHNIQUES FOR ESTIMATING COST OF AIRCRAFT SYSTEMS

A. INTRODUCTION

A parametric equation which is derived from theoretical considerations is called a model. The parameters occurring in a model usually represent quantities that have physical significance. The validity of a model rests on the procedures used to obtain values of the parameters, e.g., estimators that not only fit the data well, but also come, on the average, close to the true values and do not vary excessively from one set of experiments to the next. The process of determining parameter values with these statistical considerations in mind is termed model estimation. The utility of parametric estimation models has been effectively applied to several branches of science. (BARD, 1974, pp. 15-16) These parametric techniques are also applicable to the area of cost estimation.

Parametric cost estimating, when applied to aircraft systems, primarily utilizes physical and performance characteristics, as well as costs of previously procured items to identify the anticipated costs for a new system. A combination of system parameters, such as physical dimensions, weight, speed, etc., can be related to the total system cost. Relationships can be established in the form of mathematical equations and are referred to as Cost

Estimating Relationships (CERs). Cost elements, such as labor hours, are chosen as the dependent variable in a CER. System parameters are evaluated as independent variables in the relationship. These parametric methods can be applied to individual segments of a system life cycle or estimations can be aggregated to reflect a composite--resulting in total system cost. In the acquisition of aircraft systems, parametric cost estimating lends itself readily to developing relationships before the details of design are certain. Cost comparisons on alternative designs can also be evaluated early in the preliminary design stage as varying parameters of system cost are tested. Parametric cost estimating is a possible tool, provided accurate and sufficient data is available to evaluate the aircraft physical characteristics, performance tradeoffs, and cost impact alternatives.

Several research studies have applied parametric cost estimating methods to develop models for aircraft systems. Included are two studies that focus on software and avionics estimating methods.

B. PARAMETRIC COST ESTIMATION STUDIES

1. Planning Research Corporation (PRC R-547-A) April 1967

An early excursion into estimating airframe development and production costs was attempted by the Planning Research Corporation (PRC). The study centered on developing suitable techniques for use in program planning, cost-effectiveness studies, and evaluation of contractor proposals. This model consisted of three separate cost elements: direct manufacturing labor, manufacturing materials, and engineering and tooling (aggregated as a single element). Tooling and engineering costs were combined in order to separate recurring and nonrecurring costs for these two categories. (Sanchez, 1967, p. I-1) The model was developed by stepwise regression on a sample of forty-one propeller driven and turbojet aircraft dating from as early as 1940. Aircraft characteristics used as independent variables included speed, weight, and functions of these (e.g., speed squared). Production program characteristics included quantity produced, delivery rate, and a weight growth factor. Contractor discontinuity variables were used to represent differences in accounting practices. Time-related characteristics expressed changes in the technological state-of-the-art from 1940.

Separate estimating equations were developed for each cost element at production unit quantities of 10, 30, 100 and 300. These estimates were then used to derive cost-quantity curves to enable cost estimation for a desired quantity of production. Graphed on a logarithmic scale, the four units of production estimate points were analyzed with best fit straight line through the vertical axis. This log-linear functional form was used to provide an estimate for a single unit of production. Twelve equations were developed, four for each cost element across the levels of production, to derive three cost estimating curves. The evaluation of separate levels of production allowed for derivation of a learning curve to be expressed in unit costs. This provided for a more uniform procedure to be applied for aggregating cost elements into total costs. (Sanchez, 1967, p. I-6)

The study did not develop separate cost equations for prototype and production aircraft. The sample data utilized a wide variety of aircraft types, period of development and production, and range of manufacturing technology.

2. RAND (R-761-PR) February 1972

This report provided a set of relationships for estimating costs of military aircraft airframes in a long-range planning context. The relationships included costs of development and production with a separate set of CER equations for prototype aircraft development. The cost elements used in developing these relationships included engineering, development support, flight test operations, tooling, manufacturing labor, manufacturing material, and quality control. (Levenson, 1972, p. 1)

The relationships were obtained through analysis from data on post-World War II cargo, tanker, fighter, bomber, and trainer aircraft. The aircraft were of aluminum construction with range in speed from low subsonic to Mach 2.2. The data sample included production programs from ten different defense contractors. The estimating equations were derived by statistical multiple regression techniques. These techniques related costs or man-hours to aircraft physical and performance characteristics and to airframe production quantity. Although other potential equation forms and explanatory variables were considered and tested, exponential regression equations primarily used three independent explanatory variables: **aircraft weight, speed** and **quantity.** These three variables provided the most useful relationships for the cost elements evaluated. Little or no predictive improvement was gained by including additional physical and performance variables in determining total airframe costs. (Levenson, 1972, p. 3)

Flight test operations were evaluated as a separate cost element and comprised all costs incurred by the contractor to carry out flight tests except the cost of test aircraft. Flight test operations costs were available for 27 aircraft. Data on several aircraft were not consistent with the majority of the sample. However, because no systematic criterion for rejecting specific aircraft was apparent in the sample, the complete sample was used.

Flight test operations cost was related to speed, weight and number of test aircraft with the resulting equation (Levenson, 1972, p. 14):

$$F = .001244 \; A^{1.160} \; S^{1.371} \; Q^{1.281}$$

coefficient of correlation (unadjusted) = .97

coefficient of variation = 34 percent

where F = flight test operations cost in 1970 constant dollars

A = AMPR weight (lb)

S = maximum speed at best altitude

Q = number of flight test airframes

The uncertainty in predicting costs was addressed by this study. Since cost estimation is frequently treated as an attempt to obtain a best single-valued prediction of the cost of a new item, a level of confidence assigned to the cost equation may explain variations between initial predictions and the actual cost outcome. Factors that account for these variations may be analyzed to assess this confidence. Three primary sources of cost estimation uncertainty occurring in aircraft systems acquisition were indicated as:

1. Changes requested by the customer
2. Difficulties encountered by the contractor
3. Statistical uncertainty inherent in the estimating method--e.g., uncertainty due to failure to include all of the relevant independent variables, uncertainty due to inherent randomness in the process being modeled.

The study maintained that the effectiveness of a parametric cost model could only be analyzed with respect to the third source of uncertainty. The effects of the first two sources of uncertainty on the validity of a model could possibly be observed by analyzing the planned weight and speed against actual weight and speed of the finished aircraft in the regression model. (Levenson, 1972, p. 33)

3. J. Watson Noah Associates (FR-103-USN) September 1973

The original intent of this report was to examine aircraft Research and Development costs and derive cost relationships for their estimation. Due to the difficulty in isolating historic R & D costs, production costs were also examined.

Data from thirty-five aircraft systems were included in the research study. Airframe cost elements included engineering, tooling and manufacturing labor, and materials costs. The costs were divided into non-recurring and recurring costs. The non-recurring costs included primarily much of what is considered as Research, Test, Development and Evaluation.

These cost estimating relationships were developed using multiple regression analysis through several logical steps. First, a large number of variables in different combinations and functional forms were screened. An examination of conventional regression statistics resulted in the elimination of several alternatives. The preferred CER was developed and a prediction interval computed. The equation was then used to predict known costs for one or more aircraft which had been temporarily excluded from the data base as a form of validation and verification. If these results proved satisfactory, then all of the observations were included in the CER development and the coefficients were reestimated. (Noah, 1973, pp. 44-45)

The following candidate variables for non-recurring airframe costs were selected:

S = Maximum Speed
A = AMPR Weight
R = Ratio of gross takeoff (GTO) weight to AMPR weight
T = Technology Index
D = Complexity Dummy

Aeronautical Manufacturers' Planning Report (AMPR) weight provided a standard for consistent evaluation. Maximum speed was used for an aircraft's best altitude. Gross takeoff weight represents design gross weight for an aircraft's primary mission. The technology index variable explained the changes which occurred in airframe manufacturing technology through time trends. The complexity dummy variable was included because the CERs underestimated the costs of four aircraft (F-102, F-106, B-58 and F-111). The use of the dummy variable was justified for these aircraft due to mission or performance parameters which required significantly new and complex technology. (Noah, 1973, pp. 47-48)

The non-recurring airframe costs relationship, derived through regression analysis, resulted in the following CER predictor:

$$\text{Cost} = -5.945 + \underset{(6.43)}{.00663\ S} + \underset{(1.645)}{.05138\ T} - \underset{(3.18)}{1.4071\ R} + \underset{(7.54)}{6.74926\ D}$$

$N = 32$

$R^2 = .847$

Numbers shown in parentheses are t-ratios expressed in absolute value. All logarithms are understood to be to the base 'e'. (Noah, 1973, p. 66-67)

Cost estimation relationships for separate elements of airframe non-recurring total costs were not developed in this model.

The significance of avionics cost in aircraft system development with a current lack of avionics CERs to estimate either development or production costs was addressed in this study. Avionics CER development had not been successful up until that time due to poor data availability and quality. The study recommended categorization and reporting of avionics costs by function through required contractor cost reports.

4. RAND (R-1693-1-PA&E) May 1975

The cost estimation model developed in the 1972 RAND study (R-761-PR) elicited user concern centering on three perceived shortcomings of the model: (1) the only two major explanatory variables were weight and speed; (2) all aircraft were lumped together rather than treated as separate classes; and (3) no provision was made for taking into account changes in airframe structural materials and manufacturing methods. (Large, 1975, p. 2) As information on several new aircraft became available, the Office of the Assistant Secretary of Defense -Program Analysis and Evaluation (OSD-PA&E) sponsored a new RAND study to address these problems. The study plan called for:

1. Review of airframe data in the RAND files to ensure accuracy and consistency of definition and acquisition data on new aircraft
2. Consideration of additional explanatory variables that would make the model better able to deal with characteristics peculiar to individual aircraft, e.g., variable-geometry wing, oversize fuselage
3. Examination of the cost impact of major changes in manufacturing technology over time and of the use of different structural materials. (Large, 1975, p. 2)

In the time available, all questions concerning data consistency were not resolved. Their search for other explanatory variables that would improve the accuracy of estimates were less fruitful than they hoped. The variations in cost that were not explained by weight and speed were not explained by any other objective indexes that they could find. Since the data sample consisted largely of aluminum aircraft, the shift to other materials such as steel, titanium, and composites raises a question about the value of equations derived from that sample for estimating the cost of future aircraft. Some qualitative considerations were addressed concerning a statistical analysis trend toward higher material costs and reduced manufacturing man-hours.

The estimation model developed was similar to other RAND models in that it allowed estimates to be made of individual cost elements. The study contends that results obtained from individual cost estimates are comparable to the accuracy achieved by estimating at the total program level recommended by the 1973 Noah study (FR-103-USN).

An attempt to analyze the data sample by aircraft type (bombers, fighters, cargo aircraft, etc.) was addressed. Despite the intuitive appeal of stratifying the sample in that way, two factors discouraged this approach. First, when the data were plotted, no natural boundaries appeared. Trainers were mixed with fighters, fighters with bombers, and bombers with cargo aircraft since many category types were similar in both weight and speed. Second, the sample size for individual aircraft types was too small to be representative except in the case of fighters. They held that in cost estimation, as is usually the case, the new aircraft will be substantially different from the historical data base and it is better to have a larger group of more diverse aircraft as a data sample.

Numerous explanatory variables that could impact aircraft development cost were evaluated. Seventeen separate physical characteristics were considered as possible variables for analysis. Other factors influencing program cost were explored: **schedule, management, funding, state-of-the-art advance, availability of labor, investment in capital tools**, and **time.** However, these factors were considered to be inconsistent and not appropriate to a parametric cost model based on data from a wide assortment of programs insensitive to small changes. (Large, 1975, p. 14)

Utilizing a stepwise least-squares procedure, the explanatory variables were evaluated. The most statistically significant characteristics and dependable predictors of cost remained **weight** and **speed.** (Large, 1975, p. v)

Flight test costs were also addressed in this study as a separate cost element. The independent variables found to be significant here, other than weight and speed, were the **number of flight-test aircraft** and a **dummy variable** to distinguish between cargo aircraft and all other types. The rationale for the dummy variable focused on added cost of instrumenting the test aircraft as an important portion of flight-test cost. Thus, cost should increase as the number of aircraft increases. Cargo aircraft supposedly require less flight testing than fighters and bombers due to a relative complexity factor, so cargo aircraft flight test costs would be lower. The flight test estimating equation was presented as follows (Large, 1975, pp. 36-37):

where FT = Flight Test Cost (1973 $ in Thousands)

Wt = Airframe Unit Weight (lb)

Speed = Maximum Speed (kn)

N = Number of Test Aircraft

DV = Dummy Variable (2 - Cargo, 1 - All others)

$$\begin{array}{lllll} FT = & .13(Wt)^{.71} & (Speed)^{.59} & (N)^{.72} & (DV)^{-1.56} \\ & (.99) & (.92) & (.99) & (.99) \end{array}$$

$$R^2 = .81$$

The number under each independent variable is the level of significance of that variable.

The study provided a suggested direction for future research emphasizing not only deterministic physical and performance characteristics but also trying to understand the influence of program differences. Factors such as **schedule, experience, efficiency, economic conditions, labor scarcities**, and all other contractor and governmental concerns do have a cost impact on each individual aircraft system acquisition. (Large, 1975, pp. 53-54)

5. RAND (R-1854-PR) March 1976

This report described the development of a substantially revised RAND computer model, DAPCA III (Development and Procurement Costs of Aircraft), which superceded the previous version reported in RAND report R-761-PR. This model is based partially on airframe methodology described in R-1693-1-PA&E with all airframe costs calculated as functions of airframe unit weight and maximum speed at best altitude. Other explanatory variables found to be significant were time of first flight for manufacturing labor and for manufacturing materials, and the dummy variable for cargo or non-cargo aircraft in flight test cost. (Boren, 1976, p. 2)

No cost estimation relationships were developed for avionics packages to be included in the total system cost. Avionics development cost was entered into this model only as a throughput. Estimations for follow-on avionics packages were adjusted to follow a 95% learning curve factor since the package usually consisted of old as well as new equipment.

6. TRW Defense and Space Systems Group (ASD-TR-80-5025) September 1980

This study does not address the acquisition of the total aircraft system, rather it focuses on the **software cost analysis** and estimating procedures of **avionics operational flight programs (OFP).** It assumes limited knowledge of the software product in the early planning phases, increased knowledge before the release of the Request For Proposal (RFP), and more complete knowledge at the time of proposal evaluation and source selection. (Wolverton, 1980, p. 1) Several cost estimating methodologies and alternatives were provided to support and evaluate the validity of an initial cost estimate.

The study reviewed five traditional approaches to software cost estimation. The approaches described were top-down, similarities and differences, ratio, standards, and bottom-up estimating. It was recommended that two approaches should always be used in order to cross-check one against the other. This provided a systematic basis that would account for any observed difference in the total cost.

Four cost estimating models, that could be utilized for initial estimates or cross-checking, were described by purpose, input, computational procedures, and output. These models, believed to be most useful, included: Boeing Computer Services Cost Model, IBM Walston-Felix Cost Model, Putnam's Software Life Cycle Cost Model, and RCA PRICE Software Cost Model. These parametric estimation models predominantly use a combination of the following inputs: **units of delivered source statements, lines of source code, number of source instructions, type of software to be developed, programming language and programmer skill, programming techniques, labor cost, available manpower** or similar type descriptors. Utilizing various parametric techniques, the models provides cost estimation information in the form of man-month requirements, project duration, development cost, time phasing of effort, and sensitivity analysis to adjusted input variables.

The study recommends that each separate cost estimate be verified through comparison with an alternate prediction method.

7. RAND (N-1685-AF) March 1981

This research project was directed at providing cost estimating methods and relationships for both whole avionics suites and individual avionics systems for combat aircraft. The study centered on a sample of 17 combat aircraft and the avionics equipment installed in each. Possible explanatory variables were selected based upon interview inputs from defense contractors. Multivariate regression analysis techniques were used to evaluate potential CERs for both whole suites and individual avionics systems.

The explanatory variables determined to be most statistically significant for the avionics suites were:

1. Aircraft Empty Weight
2. Avionics Suite Weight
3. System Power Requirements (kilovoltamperes)
4. Avionics Suite Volume
5. Year of First Flight (technology variable)
6. All-weather capability dummy variable.

Four individual cost estimating relationship equations were developed based upon aircraft characteristics, avionics suite weight, avionics suite volume, and avionics suite power requirements. (Dryden, 1981, pp. v-vi)

Analysis of individual avionics systems, broken down into 11 functional groups, did not yield cost estimating relationships that were as robust as those provided for a whole avionics suite. This grouping provided relatively homogeneous subsamples with potential estimating relationships based on weight, volume and power variables. A technology variable added little to the effectiveness of tested relationships with an undesirable amount of unexplained variance remaining.

A major problem expressed in this study was the difficulty in capturing and representing the rapid change characterizing the electronics technology of avionics. Advances in that technology have consistently led to the accomplishment of more individual functions per unit size of avionics equipment. To meet increasing mission requirements, more functions have been included in the design of avionics suites with an overall increase in total cost. (Dryden, 1981, p. 2)

C. SUMMARY

The studies discussed in this chapter were developed to provide parametric cost estimating models for both development of total aircraft systems and separate cost elements of those systems. The models describing airframe costs were developed as long ago as 1967. Avionics and software costs have emerged as growing elements in the acquisition of new aircraft systems. All of these cost models were developed through multiple stepwise regression using various size databases. The statistical samples were updated and evaluated with newer aircraft designs as manufacturing methods and materials also changed. Despite the difference in samples and statistical approaches each study used for estimation, the two primary aircraft characteristics or variables/drivers for airframe cost remained weight and speed. Comparing airframe design alternatives for a new aircraft system, cost and performance tradeoffs could not be readily identified by using current estimation models unless weight and speed are significant factors in the analysis. Figure 2-1 compares four airframe cost studies by identifying cost elements and independent aircraft characteristic variables. Other physical and performance characteristics provided the most easily quantifiable descriptors of an aircraft system but did not yield the statistical qualities required to be considered for inclusion in an accurate cost model.

The need for identification of more reliable independent variables, that would provide statistical stability for cost estimation, was a salient issue addressed in these research studies. The structure and implementation of acquisition record keeping systems to provide the depth and accuracy of cost data for analysis was also considered an important focal point.

	A	B	C	D	
DEPENDENT VARIABLES					
Aircraft Recurring Cost				X	
Aircraft Non-recurring Cost				X	
Development Support Cost			X		
Engineering/Tooling Cost		X			
Flight Test Cost	X			X	
Manufacturing Labor Cost		X			
Manufacturing Materials Cost		X	X		
Quality Control Cost		X			
Tooling Cost			X		
Total Cost				X	
Engineering Hours					X
Manufacturing Hours					X
Quality Control Hours				X	
Tooling Hours					X
INDEPENDENT VARIABLES					
Cargo Dummy				X	
Quantity		X	X		X
Speed	X	X	X	X	
Time/Complexity	X		X		
Weight	X	X	X	X	

STUDIES
A. PRC R-547A (1967)
B. RAND R-761-PR (1972)
C. NOAH FR-103-USN (1973)
D. RAND R-1693-PA&E (1975)

Figure 2-1. Dependent/Independent Variables Developed For Aircraft Cost Estimating Models

III. DEVELOPMENT OF DATA BASE

A. REQUIREMENTS FOR BUILDING DATA BASE SYSTEM FOR T & E

1. Current Data Base

The system currently employed at NAVAIR is on three VAX-780's. This system does not facilitate either easy access to, amendment of, or rapid manipulation of the stored data due to heavy use by all branches of NAVAIR. The need for separate applications and more natural access to the data became evident in discussions with the sponsor. This need must also be filled by a system that is MS-DOS compatible that will integrate with their current on-line applications and other projected applications. The discussion in the next two sections suggests that a relational database would best fit the purpose of this study. A relational DBMS provides more timely information, better data integrity, data independence, better data management, and economies of scale. (Kroenke, 1983, p. 17)

2. Need for Data Manipulation

Constructing a data base would be greatly simplified if the only requirements were to estimate total program cost or total development and total production costs. For long-range planning studies, estimates at such aggregated levels may suffice, but they are of little use in understanding why a new program is estimated to cost a certain amount. An analyst often wants to be able to compare major cost drivers with their counterparts to determine whether they seem reasonable and to make adjustments wherever indicated by special characteristics of the proposed aircraft (Large, 1975, p. 8), or to make design or programmatic decisions involving tradeoffs at low levels of detail. These ad hoc inquiries necessitated a tailored data base applications program that could be easily manipulated and readily interfaced into a separate statistical analysis software package such as Statsgraphic, version 2.1 or later.

3. Need for Standardization

Achieving a perfectly consistent data base when the data have been compiled by so many different contractors is extremely difficult because accounting practices differ so greatly among companies. (Large, 1975, p. 7) Thoroughly reviewing the data supplied by the contractors (levels below the required CCDR reports) and comparing them to archival data, available through NAVAIR (CCDR reports), allowed for some standardization and normalization (see Appendix A, DATA DICTIONARY). Upon completion of this step, it then becomes necessary to select an appropriate data base package for the tailored design and implementation.

B. DESIGN AND IMPLEMENTATION

Given that the data base would be used in a Local Area Network (LAN) MIS office environment, a desk top-based DBMS with advanced user interface and full transfer capabilities to the VAX-780s would be ideal. Several excellent relational data base shells are available commercially.

dBase III+ was selected for its application parameters, user friendliness and availability of technical support. The research indicated that the basic relational composition of the data base required the ability to combine aircraft specifications and test data in many different configurations as depicted in the Bachman Diagram of the logical system (Figure 3-1).

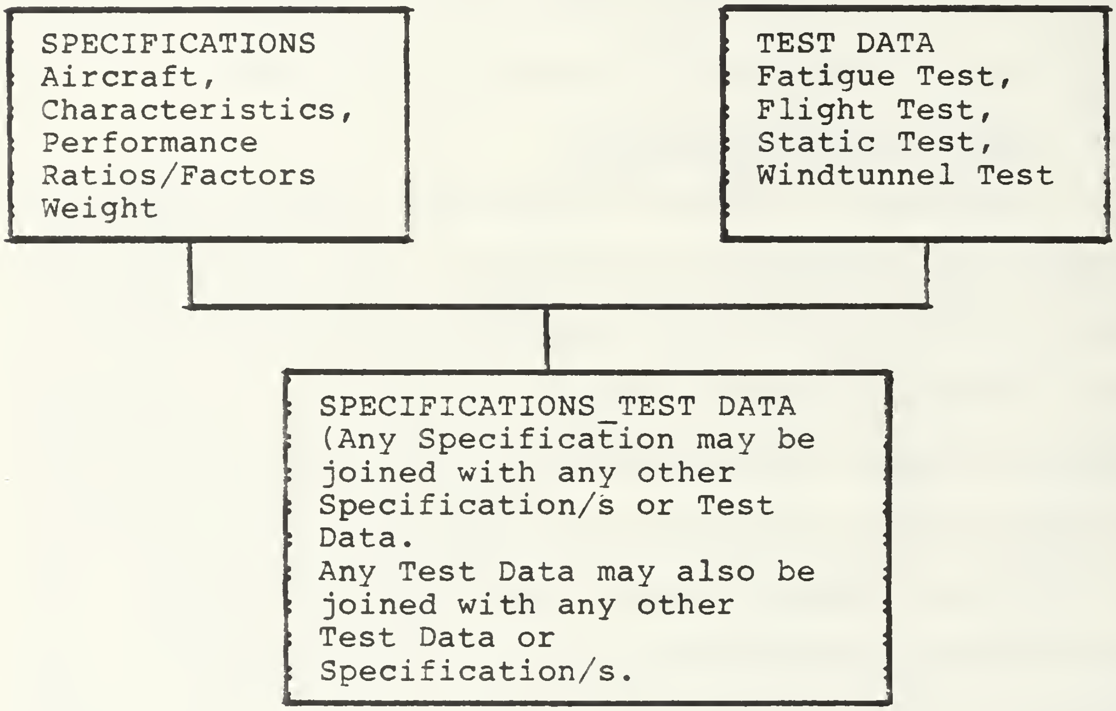


Figure 3-1. Bachman Diagram

The data was broken down at the third normal form (3NF) using the aircraft model as the key attribute. A number of predefined procedures (see Appendix B, PROGRAMS) for the manipulation of the data were compiled and a hierarchical chart was developed to enable visualization of the interrelationships of those procedures (Figure 3-2).

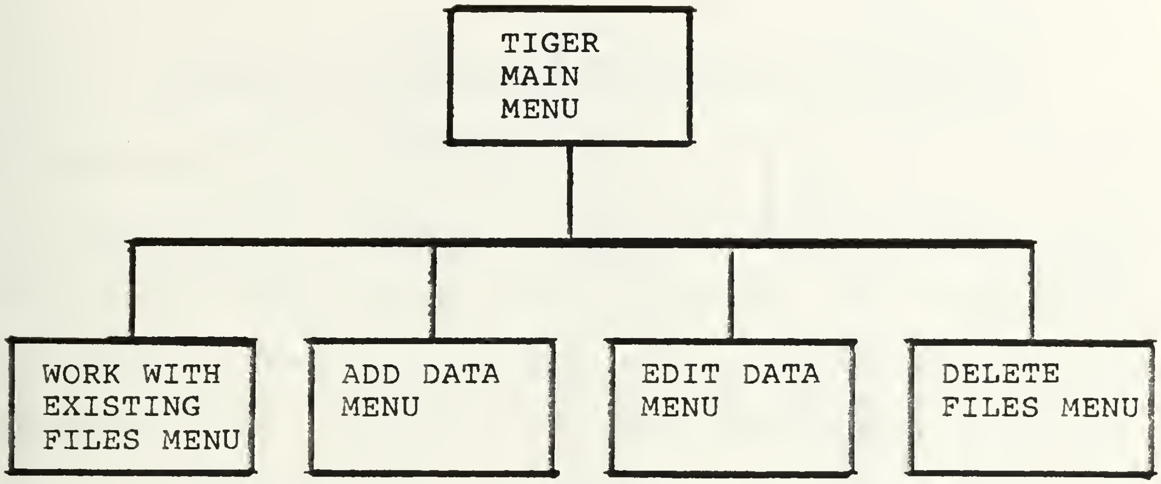


Figure 3-2. Basic Hierarchy Chart

Further decomposition led to the hierarchy depicted in Figure 3-3. The thirty-one (31) attributes and their structure (see Appendix C, DATA STRUCTURES) used in the programs evolved from this decomposition.

C. DATA BASE UTILIZATION AND BENEFITS

A User's Manual (see Appendix D, USER'S MANUAL) was developed to enhance the maintenance and portability of the applications programs. When a new aircraft is to be developed, all the available data can be inserted into the data base. Corrections to existing data as well as deletion of outdated data or entire records have also been simplified. Perhaps the major benefit of the program is its ability to merge files based on any attribute or sub-sets of attributes the analyst wishes to examine. Ad hoc queries can be processed and the analyst can review the report in a printed form (see Appendix E, REPORTS) as well as entering this newly created file into Statsgraphic, a statistical software package, to expedite the analysis process.

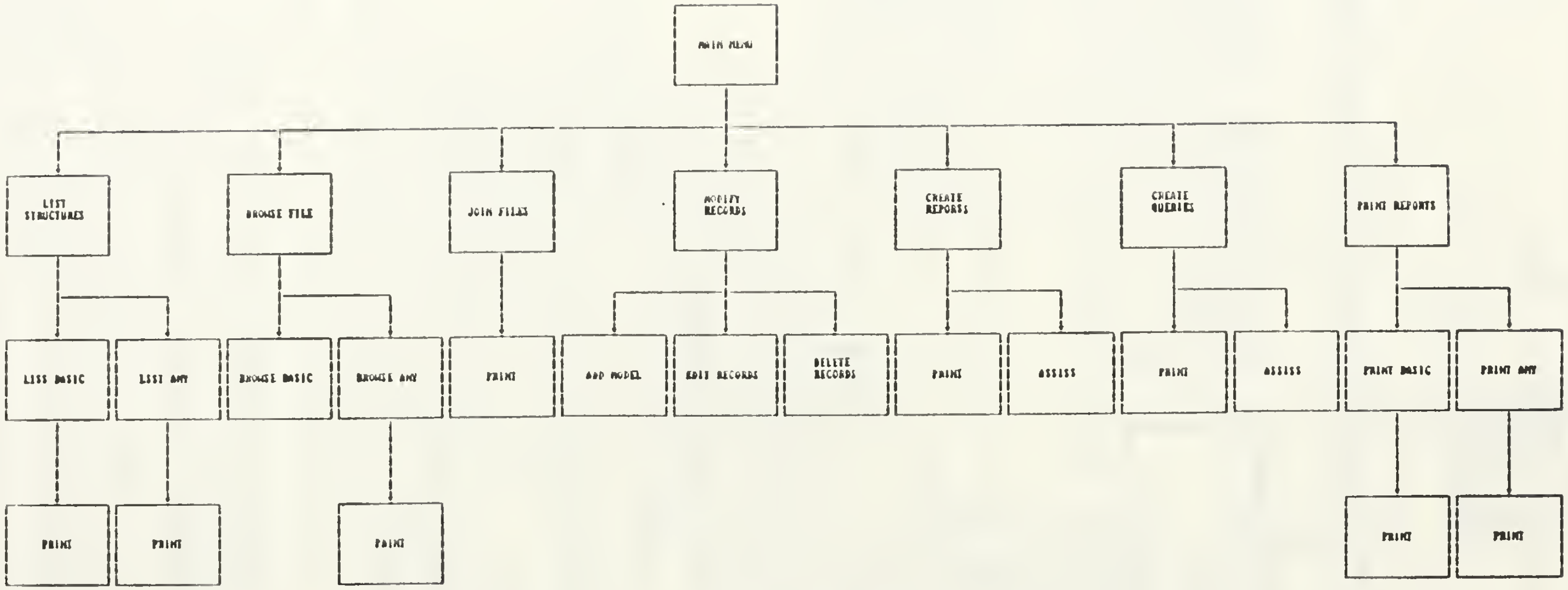


Figure 3-3. Hierarchy Chart

IV. DATA ANALYSIS OF SYSTEM TEST AND EVALUATION

A. DISCUSSION OF DATA STRUCTURES

As discussed in Chapter I, the data received were broken down into two basic categories, dependent and independent variables. These two types of variables are further described below. Appendix C (DATA STRUCTURE) lists all these variables as they are grouped into categories in the data base.

1. Dependent Variables

In the analysis process, we are trying to determine a relationship between the physical and performance characteristics of an aircraft and its test costs. The System Test and Evaluation data requested from the Defense Contractors and NAVAIR focused on direct labor hours. Direct labor hours have proven consistent in evaluating costs without regard to inflationary dollar values. Engineering, manufacturing, tooling, quality control, logistic support and total direct labor hours for the Work Breakdown Structure sub-elements of Contractor Flight Test, Static Test, Fatigue Test and Wind Tunnel Test are used as dependent variables for analysis. Standardized Work Breakdown Structure definitions of these direct labor hour cost elements as provided in Volume I, Chapter III.

2. Independent Variables

Data on aircraft physical and performance specifications are provided by Defense Contractors, NAVAIR, Aircraft Cost Handbooks (Noah, 1973; Day, 1982) and Jane's All the Worlds Aircraft reference series (1948 to present). This reference material allows an initial grouping of independent variables for estimation. The potential variables are chosen based on the availability of data, identification as proven cost drivers in previous research and expert recommendations (i.e., contractors, NAVAIR and Flight Test Centers). These specifications are separated into the following sub-categories:

- a. Characteristics -
    - Number of Crew
    - Date of First Flight
    - Aircraft Wetted Area
    - Fuselage Volume
    - Wing Loading
    - Carrier Capable
    - Number of Avionics Boxes
    - Number of Engines
    - Number of Store Stations
    - Thrust
- b. Ratios/Factors -
    - Limit Load Factor
    - Ultimate Load Factor
    - Empty Weight Divided by Structure Weight

	Empty Weight Divided by Aircraft Volume
	Gross Takeoff Weight Divided by Structure Weight
c. Weight -	Structure Weight
	Airframe Unit Weight
	Empty Weight
	Gross Takeoff Weight
	Uninstalled Avionics Weight
	Installed Avionics Weight
	Maximum Structural Store Weight.
d. Performance -	Maximum Speed at Optimum Alt
	Maximum Speed at Sea Level
	Cruise Speed
	Combat Ceiling
	Service Ceiling
	Combat Radius

The complete data structure listing of both the dependent and independent variables are contained in Appendix C (DATA STRUCTURE).

3. Statistical Analysis Data Format

Multiple linear and non linear regression were performed. The process started by developing correlation matrices and then selecting initial independent variables with the highest correlation relating to the dependent variables and low inter-variable correlation with other independent variables. The regression procedure fits a model relating one dependent variable to one or more independent variables by minimizing the sum of the squares of the residuals for the fitted line. Linear, multiplicative and exponential models were used. In the multiplicative and exponential models, the dependent variable is first transformed by taking its natural logarithms. Then, the model parameters are estimated. The results are then plotted using the fitted lines.

B. EVALUATION OF DATA

1. Statistical Value of the Data

The data available for analysis are given in Appendix D. During the screening process, it was determined that only Engineering hours and Total hours cost elements within the Contractor Flight Test WBS sub-category contained sufficient data points to permit statistically valid analysis. Although much of the Static Test, Fatigue Test and Wind Tunnel Test data were consistent and complete for several aircraft, there were not enough data reported in these sub-categories to lend statistical significance for the use of these cost elements as dependent variables.

The data representing both dependent and independent variables were entered into a data base to facilitate analysis and grouping of the data. The specific data points available for analysis in this study are represented in

Appendix E. Due to the proprietary nature of the data, the presence of data is represented by an 'XX' corresponding to a the applicable cost element or physical/performance characteristic.

NAVAIR supplied standardized data from historical records. This data was used to validated some of the labor hours provided by Defense Contractors. Not all of this data was able to be standardized as discussed in Chapter I. However, it was determined that this data should be included so that initial analysis could be conducted with the largest possible sample size. It is envisioned that NAVAIR will continue further collection and standardization of this data so that more definitive statistical analysis can be accomplished as data becomes available.

C. ANALYSIS OF COST DRIVERS

As independent variables were initially evaluated for consideration as cost drivers, a one-sample analysis was performed to indicate data consistency (Statgraphics, 1986 p. 11-2). A histogram plot of variables with greater than ten data points was developed. This enabled an analysis of both data groupings and variable comparison of physical/ performance characteristics. The resulting one-sample analysis and histograms are contained in Appendix F.

All of the independent variables were considered for potential analysis. Several were evaluated as not having sufficient data points required for successful multiple regression techniques. The following cost drivers were considered to have the most significant impact for cost estimation modeling: Number of Crew (CREW), Date of First Flight (FF), Wing Loading (WL), Carrier Qualified(CQ), Number of Engines (ENG), Thrust, Empty Weight Divided by Structure Weight (WEOWS or WE/WS), Gross Takeoff Weight Divided by Structure Weight (GTOWOWS or GTOW/WS), Structure Weight (WS), Empty Weight (WE), Gross Takeoff Weight (GTOW), Uninstalled Avionics Weight (WAVU), Installed Avionics Weight (WAVI), Maximum Speed at Optimum Altitude (VMAXA), Maximum Speed at Sea Level (VMAXS), Cruise Speed (VCRUISE), Combat Ceiling (CBCEIL), Service Ceiling (SERCEIL) and combinations of the above.

D. DEVELOPMENT OF COST DRIVER MODELS

Both stepwise least-squares procedures and single step multiple regression techniques were used to determine the best cost driver models. All of the potential independent variables were tested with respect to dependent variables of Contractor Flight Test Engineering and Total direct labor hours. During the initial regression, a F-ratio of 4.0 was used as a threshold for inclusion of independent variables in the equation. Past historical studies showed that certain particular variables were not determined to influences the cost (Rand, 1975, p.16). However, we eliminated the independent variables based solely on their statistical insignificance. The multiple-regression package used calculates the usual statistical measures of fit and provides plots of the fit. This package eliminates observations with missing data points thereby decreasing the sample size for analysis. These results are shown with the development of each equation in APPENDIX G. In selecting preferred equations, a high coefficient of determination (R^2), the F statistic for tests concerning the equality of the independent variables standard deviations, and the independent T values are the basis for variables initially being included in the regression. Both linear and logarithmic regression were used. Although logarithmic regression minimizes relative errors, some extremely valuable linear equations were found which had as good if not better statistical significance.

1. Contractor Flight Test Total Labor Hours

a. Weight and Speed Variables

The independent variables initially used with the Total Hours cost element were selected from the outcomes of previous studies and expert opinion, in this area, focusing on aircraft weight and speed. All variables of weight and speed, including ratios of both, were evaluated as potential cost drivers. It was found that the non-availability of complete data created a wide variation in the outcomes of the analysis. With a large sample size, the statistical significance of the equation was less than that of one with a small sample size.

Utilizing only two independent variables--weight and speed--the following log-linear equation resulted:

EQUATION 1 (Refer to pp. 184, 185)

$$TOTALHRS = -1.64\ (VMAXA)^{1.67}\ (WEOWS)^{-2.89}$$

$R2 = .59$

F-Ratio = 11.56

19 Observations

Utilizing stepwise regression, including all the weight, speed and weight ratio variables, the most conclusive relationship developed, resulting in the following log-linear equation and relating statistics:

EQUATION 2 (Refer to pp. 186, 187)

$$TOTALHRS = -10.89\ (WS)^{.99}\ (VMAXS)^{1.47}$$

$R2 = .95$

F-Ratio = 69

10 Observations including: A-10, A-4, A-5, A-6,
F-14, F-15, F-4, F/A-18, S-3, T-38

Both of these relationships are statistically sound. What also must be considered is the observation size which was reduced by the inclusion of other independent variables with less data availability.

b. Consideration of Other Variables

As the other potential cost drivers were also considered, several variables emerged as being consistently reliable. These included characteristics, performance and avionics weight factors. Interestingly, avionics weight emerged as particularly significant independent variable when used as a percentage factor of either Aircraft Structure Weight (WS) or Empty Weight (WE). This component provided a sizing factor for avionics that provided an easy comparison across all types of aircraft. The integration of avionics accounts for a large number of direct labor hours in the Contractor Flight Test effort. This allows for consideration of avionics as an important cost driver. In the past, avionics was overlooked. It was only considered as a portion of total airframe weight.

With these variables considered, the analysis yielded the following estimated equation:

EQUATION 3 (Refer to pp. 196, 197)

$$\text{TOTALHRS} = -6726.84 + 2.33\,(\text{VMAXA}) + 35.22\,(\text{WL}) + 97.29\,(\text{WE/WAVI}) + .13\,(\text{WE})$$

$R^2 = .95$

F-Ratio = 36.4

12 Observations

As more physical and performance characteristics were introduced, the sample size evaluated through stepwise multiple regression decreased again due to missing data points. This small sample size consisted of a more homogeneous grouping of aircraft by type and weight (<100,000 lbs.). The evaluation of this sample grouping with more independent variables yielded a statistically significant result. The following was obtained from the analysis:

EQUATION 4 (Refer to pp. 220, 221)

$$TOTALHRS = 6.87\ (VMAXA)^{.70}(WS/WAVI)^{18.75}(WAVU)^{2.43}(GTOW)^{-17.03}(GTOW/WS)^{17.13}$$

$R2 = .98$

F-Ratio = 62.1

11 Observations

EQUATION 5 (Refer to pp. 222, 223)

$$TOTALHRS = -\ 6.32\ (VMAXA)^{.82}(WS/WAVI)^{1.12}$$

$R2 = .92$

F-Ratio = 57.1

13 Observations

EQUATION 6 (Refer to pp. 224, 225)

$$TOTALHRS = -6765.36 + 2.34\ (VMAXA) + 30.94\ (WL) + 101.32\ (WS/WAVI) + 0.15\ (WE)$$

$R2 = .95$

F-Ratio = 41.5

13 Observations

2. Contractor Flight Test Engineering Hours

a. Weight and Speed Variables

The independent variables used with the Engineering direct labor hours cost element were selected with the same criteria and constraints as in Total Hours.

Utilizing only two independent variables--weight and speed--the following log-linear equation were derived:

EQUATION 7 (Refer to pp. 230, 231)

$$ENGHRS = 0.23\ (VMAXA)^{1.29}\ (WEOWS)^{-2.67}$$

$R2 = .48$

F-Ratio = 6.8

18 Observations

Utilizing stepwise regression, including all the weight, speed and weight ratio variables, the most conclusive relationship emerged, resulting in the following linear equations and related statistics:

EQUATION 8 (Refer to pp. 232, 233)

$$ENGHRS = -664.71 + 0.23\ (WS) + 1.73\ (VMAXA) - 0.04\ (GTOW)$$

$R2 = .91$

F-Ratio = 25.02

11 Observations including: A-10, A-4, A-5, A-6, AV-8B, F-14, F-15, F-4, F/A-18, S-3, T-38.

Both of these relationships are statistically valid with the considerations as mentioned with Total Hours.

b. Consideration of Other Variables

The same independent variables used in Total Hours were evaluated. With these variables considered, the following relationship of cost drivers yielded the following results:

EQUATION 9 (Refer to pp. 236, 237)

$$ENGHRS = 165.13 + 3.21\,(VMAXA) + 67.20\,(FF) - 2143.66\,(THRUST/WE)$$

R2 = .71

F-Ratio = 10.6

17 Observations

A smaller sample size of aircraft with Gross Takeoff Weight less than 100,000 lbs. resulted in the following analysis:

EQUATION 10 (Refer to pp. 242, 243)

$$ENGHRS = -574.34 + 0.72\,(VMAXA) + 7.85\,(WL) + 29.2\,(WS/WAVI) + 0.37\,(WAVU) + 0.22\,(WE) - 0.07\,(GTOW) - 18.22\,(FF) - 706.75\,(CREW)$$

R2 = .998

F-Ratio = 170.17

11 Observations including: A-10, A-4, A-5, A-6, AV-8B, F-14, F-15, F-4, F/A-18, S-3, T-38.

EQUATION 11 (Refer to pp. 244, 245)

$$ENGHRS = 1.1\,(VMAXA)^{.89}(WS/WAVI)^{2.24}(GTOW)^{-1.52}$$

R2 = .79

F-Ratio = 12.7

14 Observations

E. SUMMARY

Contractor Flight Test Total direct labor hours proved to be a more stable dependent variable than Engineering direct labor hours. The best cost drivers were determined using a sample size with Gross Takeoff Weight restricted to less than 100,000 lbs. In most relationships, the avionics weight percentage factor emerged as particularly significant independent variable.

No best cost model can be recommended at this point due to lack of data causing variance in observation size between cost estimating relationships.

V. SUMMARY

The purpose of this research was to review the current cost estimating structure in Aircraft Systems Test and Evaluation and provide better cost estimation models, with particular emphasis on Contractor Flight Test elements.

A. SUMMARY OF RESULTS

As a result of extensive field investigation, data collection, database design and implementation and parametric modeling, the major findings of this research are enumerated below:

1. Propositions for a better implementation of the CCDR

The Contractor cost Data Reporting (CCDR) system was established to provide the DOD with continual ability to develop and use valid cost estimates (Chapter II, Volume I). However, from a cost estimation standpoint, current practices of the CCDR system suffer from numerous shortcomings. First, CCDR reports have often been inconsistent across contractors due to ambiguity in defining cost elements. Second, dual source and sub-contracts are more than frequently granted. Contractors habitually cannot, or do not want to cooperate with other contractors. Third, cost data have not been reported regularly enough for time-series analysis.

This research proposed a number of courses of action that could at least correct some of these shortcomings for more meaningful and accurate data analysis: (1) factor the Work Breakdown Structure (WBS) into lower levels, (2) provide time-phased data reporting, and (3) implement a well-defined CCDR data base system (Chapter III, Volume I). Furthermore, this study suggested an eventual restructurization of the WBS by revising the hierarchy of the WBS elements.

2. Elicitation of experts' opinion to identify the most important cost-drivers in System Test and Evaluation

Past scientific studies have primarily considered weight, speed and the number of aircraft as the most statistically significant cost estimators. Due to technological innovations, other cost drivers have recently emerged. This study conducted a nation-wide field investigation. The following factors were identified as essential cost drivers: mission, aircraft weight, aircraft speed, avionics complexity, software, power supplies, data reduction, number of test aircraft, delivery schedule, joint contractor/ military testing and political environment (Chapter V, Volume I).

The interviews with defense contractors and military test centers also resulted in numerous recommendations for improvement of the current process of System Test and Evaluation. Among these, the following strategies have triggered substantial interest: (1) use of simulation in software testing, (2) use of structured analysis and design methodology to develop software, (3) implementation of distributed systems using parallel process, (4) development of more efficient power units to reduce weight and volume of avionics of aircraft, (5) reduction of the required number of test aircraft, and (6) delivery of aircraft in a block (phase program). In addition, in a longer perspective, further studies are necessary to determine if joint testing is producing the highest quality and most cost-efficient aircraft.

3. Survey of Current Data and Structure Maintained by Defense Contractors and Military Institutions

As an effort to gather data for cost modeling, this research gathered data from defense contractors and military test centers. Data were provided by Boeing, Rockwell International at Columbus, Fairchild, Grumman Aerospace Corporation, Rockwell International at Los Angeles, LTV Aerospace and Defense, General Dynamics, McDonnell Douglas, Lockheed Georgia, Lockheed California, the Naval Air Test Center, the Air Force Test Flight Center, and NAVAIR. It was found that some data were better and more complete than others. It was also found that some data requested could not be obtained (Chapter I, Volume II).

4. Survey of Parametric Techniques for Estimating Cost of Aircraft Systems

Avionics and software costs have emerged as growing elements in the acquisition of new aircraft systems.

Despite the difference in samples and statistical approaches each study used for estimation, the two primary aircraft characteristics or variables/drivers for airframe cost remained weight and speed.

The need for identification of more reliable independent variables, that would provide statistical stability for cost estimation, was a salient issue addressed in these econometric estimations. The structure and implementation of acquisition record keeping systems to provide the depth and accuracy of cost data for analysis were also considered an important focal point.

5. Development of a Cost Estimation Relational Data Base System

The current NAVAIR system does not facilitate either easy access to, amendment of, or rapid manipulation of the stored data for cost estimation due to heavy use by all branches of NAVAIR. The need for separate applications and more natural access to the data became evident in discussions with the sponsor. This need must also be filled by a system that is MS-DOS compatible and will integrate with current on-line applications and other projected applications.

Given that the data base would be used in a Local Area Network (LAN) MIS office environment, a desk top-based DBMS with advanced user interface and full transfer capabilities to the VAX-780s would be ideal was implemented using dBase III Plus (Chapter III, Volume II).

6. Development of New Parametric Cost Estimation Models

Contractor Flight Test Total direct labor hours proved to be a more stable dependent variable than Engineering direct labor hours. The best cost drivers were determined using a sample size with Gross Takeoff Weight restricted to less than 100,000 lbs. In most relationships, the avionics weight percentage factor emerged as a particularly significant independent variable (Chapter IV, Volume II).

B. SUGGESTIONS FOR FUTURE RESEARCH

The conclusions developed through the statistical analysis are extensions and improvements on the previous studies cited. As more data are collected, standardized and inputted the equations developed should increase in accuracy. The rapidly changing "state of the art" in avionics and its commensurate effects on cost estimation and analysis of aircraft systems that have been previously identified, continues to be of concern. This effect on cost estimation will not be solved until a method of collection of engineering and total hours in the WBS and CCDR is adopted at lower levels than previously used. This paucity of data hampered this research and undoubtably will hamper future research and consequently the accuracy of estimation on proposed aircraft. The groundwork had been laid, this takes that groundwork but one step further. It is hoped that this thesis will be of value to both the public and private sectors. The challenge to future research lies in the adoption of measures to insure clarity across both contractor and government lines. Then, precision and accuracy can be insured.

APPENDIX A: DATA DICTIONARY

AIRCRAFT = MODEL + MISSION + MFG

AVBX = Number of avionics boxes in aircraft system

AWA = Aircraft wetted area

CBT_CEIL = Maximum rated combat ceiling

CBT_RADIUS = Radius of operation for combat purposes in miles

CHAR = MODEL + CREW + FIRST_FLT + AWA + VOL + WL + CQ + AVBX + ENG + SSTA + THRUST

CREW = Number of crew members

CQ = Is the aircraft carrier qualified

ENG = Number of engines

ENGHR = Number of engineering hours spent on flight testing

FATIGUE = MODEL + FTMOS + FTHRS + FENGHRS + FMFGHRS + FTOOLHR + FQCHRS + FILSHRS + FTOTHRS

FENGHRS = Number of engineering hours spent on fatigue testing

FILSHRS = Number of integrated logistic support hours spent on fatigue testing

FIRST_FLT = Date of first flight since 1952

FLIGHT = MODEL + FLTHRS + TEVTS + ENGHR + MFGHR + TOOLHR + QCHR + ILSHR + TOTHRS

FLTHRS = Number of hours the aircraft spent in actual flight testing

FMFGHRS = Number of manufacturing hours spent on fatigue testing

FQCHRS = Number of quality control hours spent on fatigue testing

FTHRS = Number of hours the aircraft spent in actual fatigue testing

FTMOS = Number of months the aircraft underwent fatigue testing

FTOOLHR = Number of tooling hours spent on fatigue testing

FTOTHRS = Total number of hours spent on fatigue testing

GTOW = Gross takeoff weight

GTOW/WS = Gross takeoff weight/Structure weight

ILSHR = Number of integrated logistic support hours spent on flight testing

LLF = Load limit factor

MAXWSS = Maximum structure stores weight

MFG = Manufacturer's Name

MFGHR = Number of manufacturing hours spent on flight testing

MISSION = [ASW | Attack | Bomber | Early War | EW Fighter | Patrol | Recon | Trainer | Transport]

MODEL = Aircraft's model number

PERFORMA = MODEL + THRUST + VMAXA + VMAXS + VCRUISE + CBT_CEIL + SER_CEIL + CBT_RADIUS

QCHR = Number of quality control hours spent on flight testing

SENGHRS = Number of engineering hours spent on static testing

SER_CEIL = Maximum rated ceiling

SILSHRS = Number of integrated logistic support hours spent on static testing

SMFGHRS = Number of manufacturing hours spent on static testing

SQCHRS = Number of quality control hours spent on static testing

SSTA = Number of aircraft store stations

STATIC = MODEL + STMOS + SENGHRS + SMFGHRS + STOOLHR + SQCHRS + SILSHRS + STOTHRS

STMOS = Number of months the aircraft underwent static testing

STOOLHR = Number of tooling hours spent on static testing

STOTHRS = Total number of hours spent on static testing

TEVTS = Number of separate specific tests performed during the flight testing

THRUST = [Pounds of Thrust | Shaft Horsepower | Horsepower]

TOOLHR = Number of tooling hours spent on flight testing

TOTHRS = Total number of hours spent on flight testing

ULF = Unlimited load factor

VCRUISE = Normal cruising speed in knots

VMAXA = Maximum speed at optimum altitude

VMAXS = Maximum speed at sea level

VOL = Fuselage volume

WA = Aircraft unit weight

WAVI = Installed avionics weight

WAVU = Uninstalled avionics weight

WE = Empty weight of the aircraft

WE/VOL = Empty weight/Volume

WE/WS = Empty weight /Structure weight

WEIGHT = MODEL + WS + WA + WE + GTOW + WAVU + WAVI + MAXWSS

WENGHRS = Number of engineering hours spent on wind tunnel testing

WILSHRS = Number of integrated logistic support hours spent on wind tunnel testing

WIND = MODEL + WTMOS + WTHRS + WENGHRS + WMFGHRS + WTOOLHR + WQCHRS + WILSHRS + WTOTHRS

WL = Wing strength measured in pounds per square foot

WMFGHRS = Number of manufacturing hours spent on wind tunnel testing

WQCHRS = Number of quality control hours spent on wind tunnel testing

WS = Structure weight

WTHRS = Number of hours the aircraft spent in actual wind tunnel testing

WTMOS = Number of months the aircraft underwent wind tunnel testing

WTOOLHR = Number of tooling hours spent on wind tunnel testing

WTOTHRS = Total number of hours spent on wind tunnel testing

APPENDIX B: PROGRAMS

```
* Program..: ADDMOD.PRG
* Author...: TUNG'S TIGERS
* Purpose..: Allows user to add models to the basic files.
* Date.....: 12/05/86
* I/O Files: AIRCRAFT.DBF, CHAR.DBF, FATIGUE.DBF, FLIGHT.DBF,
*            PERFORMA.DBF, RATIOS.DBF, STATIC.DBF,
*            WEIGHT.DBF, WIND.DBF
* Called By: TIGER.PRG, MODMENU.PRG
* Calls Mod: NONE
* Reserved.: selectnum
* Variables: NONE

SET TALK OFF
SET BELL OFF
SET STATUS ON
SET ESCAPE ON
SET CONFIRM OFF

SET COLOR TO GR+/B+
   * ---Display menu options, centered on the screen.
   *    draw menu border and print heading

   CLEAR
         USE ADDFILE
         APPEND
         CLEAR

@ 12,22 SAY [ADDING MODELS TO ALL BASIC FILES.....]

         USE AIRCRAFT
         APPEND FROM ADDFILE
         SORT ON MODEL TO TEMPSORT.DBF
         CLOSE ALL
         ERASE AIRCRAFT.DBF
         RENAME TEMPSORT.DBF TO AIRCRAFT.DBF

         USE CHAR
         APPEND FROM ADDFILE
         SORT ON MODEL TO TEMPSORT.DBF
         CLOSE ALL
         ERASE CHAR.DBF
         RENAME TEMPSORT.DBF TO CHAR.DBF

         USE PERFORMA
         APPEND FROM ADDFILE
         SORT ON MODEL TO TEMPSORT.DBF
         CLOSE ALL
         ERASE PERFORMA.DBF
         RENAME TEMPSORT.DBF TO PERFORMA.DBF
```

```
        USE WEIGHT
        APPEND FROM ADDFILE
        SORT ON MODEL TO TEMPSORT.DBF
        CLOSE ALL
        ERASE WEIGHT.DBF
        RENAME TEMPSORT.DBF TO WEIGHT.DBF

        USE RATIOS
        APPEND FROM ADDFILE
        SORT ON MODEL TO TEMPSORT.DBF
        CLOSE ALL
        ERASE RATIOS.DBF
        RENAME TEMPSORT.DBF TO RATIOS.DBF

        USE FATIGUE
        APPEND FROM ADDFILE
        SORT ON MODEL TO TEMPSORT.DBF
        CLOSE ALL
        ERASE FATIGUE.DBF
        RENAME TEMPSORT.DBF TO FATIGUE.DBF

        USE FLIGHT
        APPEND FROM ADDFILE
        SORT ON MODEL TO TEMPSORT.DBF
        CLOSE ALL
        ERASE FLIGHT.DBF
        RENAME TEMPSORT.DBF TO FLIGHT.DBF

        USE STATIC
        APPEND FROM ADDFILE
        SORT ON MODEL TO TEMPSORT.DBF
        CLOSE ALL
        ERASE STATIC.DBF
        RENAME TEMPSORT.DBF TO STATIC.DBF

        USE WIND
        APPEND FROM ADDFILE
        SORT ON MODEL TO TEMPSORT.DBF
        CLOSE ALL
        ERASE WIND.DBF
        RENAME TEMPSORT.DBF TO WIND.DBF

*       SET CONFIRM OFF
*       STORE ' ' TO wait_subst
*       @ 23,0 SAY 'Press any key to continue...' GET wait_subst

*       READ
*       SET CONFIRM ON
        CLEAR
        USE ADDFILE
        ZAP
RETURN
* EOF: ADDMOD.PRG
^Z
```

```
* Program..: BROANY.PRG
* Author...: TUNG'S TIGERS
* Purpose..: Allows the user to browse any current database file
* Date.....: 01/01/80
* I/O Files: Any database file selected by user.
* Called By: TIGER.PRG, BROWMENU.PRG
* Calls Mod: PRINT.PRG
* Reserved.: selectnum
* Variables: NONE

SET TALK OFF
SET BELL OFF
SET STATUS ON
SET ESCAPE ON
SET CONFIRM OFF

DO WHILE .T.
SET COLOR TO GR+/B+
   * ---Display menu options, centered on the screen.
   *    draw menu border and print heading

   CLEAR
   @ 2, 0 TO 12,79 DOUBLE
   @ 3,15 SAY [B R O W S E   C U R R E N T   F I L E S   M E N U]
   @ 4,1 TO 4,78 DOUBLE
   * ---display detail lines
   @  7,31 SAY [1. BROWSE ANY FILE]
   @  8,31 SAY [2. LIST FILES]
   @ 10, 31 SAY '0. EXIT'
   STORE 0 TO selectnum
   @ 12,33 SAY " select     "
   @ 12,42 GET selectnum PICTURE "9" RANGE 0,2

  READ

  DO CASE

     CASE selectnum = 0
         SET TALK ON
         CLEAR ALL
         RETURN

     CASE selectnum = 1
      *  DO BROWSE ANY FILE
         ACCEPT [Enter filename....] to BROFILE
         USE &BROFILE
         GO TOP
         BROWSE
*        SET CONFIRM OFF
*        STORE ' ' TO wait_subst
*        @ 23,0 SAY 'Press any key to continue...' GET wait_subst
*        READ
*        SET CONFIRM ON
```

```
     CASE selectnum = 2
      *   DO LIST FILES
         DO PRINT
         DIR *.DBF
         SET PRINT OFF
         SET CONFIRM OFF
         STORE ' ' TO wait_subst
         @ 23,0 SAY 'Press any key to continue...' GET wait_subst
         READ
         SET CONFIRM ON

ENDCASE

ENDDO T

RETURN

* EOF: BROANY.PRG

^Z
```

```
* Program..: BROBASIC.PRG
* Author...: TUNG'S TIGERS
* Purpose..: This option allows the user to browse the basic data
*            files.
* Date.....: 12/06/86
* I/O Files: AIRCRAFT.DBF, CHAR.DBF, FATIGUE.DBF, FLIGHT.DBF,
*            PERFORMA.DBF, RATIOS.DBF, STATIC.DBF,
*            WEIGHT.DBF, WIND.DBF
* Called By: TIGER.PRG, BROWMENU.PRG
* Calls Mod: NONE
* Reserved.: selectnum
* Variables: NONE

SET TALK OFF
SET BELL OFF
SET STATUS ON
SET ESCAPE ON
SET CONFIRM OFF

DO WHILE .T.
SET COLOR TO GR+/B+
   * ---Display menu options, centered on the screen.
   *    draw menu border and print heading

   CLEAR
   @ 2, 0 TO 19,79 DOUBLE
   @ 3,18 SAY [B R O W S E   B A S I C   F I L E S   M E N U]
   @ 4,1 TO 4,78 DOUBLE
   * ---display detail lines
   @  7,31 SAY [1. AIRCRAFT]
   @  8,31 SAY [2. CHARACTERISTICS]
   @  9,31 SAY [3. PERFORMANCE]
   @ 10,31 SAY [4. RATIOS/FACTORS]
   @ 11,31 SAY [5. WEIGHT]
   @ 12,31 SAY [6. FATIGUE TEST]
   @ 13,31 SAY [7. FLIGHT TEST]
   @ 14,31 SAY [8. STATIC TEST]
   @ 15,31 SAY [9. WIND TUNNEL TEST]
   @ 17, 31 SAY '0. EXIT'
   STORE 0 TO selectnum
   @ 19,33 SAY " select     "
   @ 19,42 GET selectnum PICTURE "9" RANGE 0,9

   READ

   DO CASE

      CASE selectnum = 0
         SET TALK ON
         CLEAR ALL
         RETURN
      CASE selectnum = 1
      *   DO AIRCRAFT
         USE AIRCRAFT
          GO TOP
          BROWSE
*        SET CONFIRM OFF
*        STORE ' ' TO wait_subst
*        @ 23,0 SAY 'Press any key to continue...' GET wait_subst
*        READ
*        SET CONFIRM ON

      CASE selectnum = 2
      *   DO CHARACTERISTICS
         USE CHAR
         GO TOP
         BROWSE
*        SET CONFIRM OFF
*        STORE ' ' TO wait_subst
*        @ 23,0 SAY 'Press any key to continue...' GET wait_subst
*        READ
*        SET CONFIRM ON

      CASE selectnum = 3
      *   DO PERFORMANCE
         USE PERFORMA
         GO TOP
         BROWSE
*        SET CONFIRM OFF
*        STORE ' ' TO wait_subst
*        @ 23,0 SAY 'Press any key to continue...' GET wait_subst
*        READ
*        SET CONFIRM ON

      CASE selectnum = 4
      *   DO RATIOS/FACTORS
         USE RATIOS
         GO TOP
         BROWSE
*        SET CONFIRM OFF
*        STORE ' ' TO wait_subst
*        @ 23,0 SAY 'Press any key to continue...' GET wait_subst
*        READ
*        SET CONFIRM ON

     CASE selectnum = 5
      *   DO WEIGHT
         USE WEIGHT
         GO TOP
         BROWSE
*        SET CONFIRM OFF
*        STORE ' ' TO wait_subst
*        @ 23,0 SAY 'Press any key to continue...' GET wait_subst
*        READ
*        SET CONFIRM ON
```

```
      CASE selectnum = 6
      *  DO FATIGUE TEST
         USE FATIGUE
         GO TOP
         BROWSE
*        SET CONFIRM OFF
*        STORE ' ' TO wait_subst
*        @ 23,0 SAY 'Press any key to continue...' GET wait_subst
*        READ
*        SET CONFIRM ON

      CASE selectnum = 7
      *  DO FLIGHT TEST
         USE FLIGHT
         GO TOP
         BROWSE
*        SET CONFIRM OFF
*        STORE ' ' TO wait_subst
*        @ 23,0 SAY 'Press any key to continue...' GET wait_subst
*        READ
*        SET CONFIRM ON

      CASE selectnum = 8
      *  DO STATIC TEST
         USE STATIC
         GO TOP
         BROWSE
*        SET CONFIRM OFF
*        STORE ' ' TO wait_subst
*        @ 23,0 SAY 'Press any key to continue...' GET wait_subst
*        READ
*        SET CONFIRM ON

     CASE selectnum = 9
      *  DO WIND TUNNEL TEST
         USE WIND
         GO TOP
         BROWSE
*        SET CONFIRM OFF
*        STORE ' ' TO wait_subst
*        @ 23,0 SAY 'Press any key to continue...' GET wait_subst
*        READ
*        SET CONFIRM ON

ENDCASE

ENDDO T

RETURN

* EOF: BROBASIC.PRG

^Z
```

```
* Program..: BROWMENU.PRG
* Author...:  TUNG'S TIGERS
* Purpose..: This option allows the user to select the browse
*            option he wants
* Date.....: 01/01/80
* I/O Files: NONE
* Called By: TIGER.PRG
* Calls Mod: BROBASIC.PRG, BROANY.PRG
* Reserved.: selectnum
* Variables: NONE

SET TALK OFF
SET BELL OFF
SET STATUS ON
SET ESCAPE ON
SET CONFIRM OFF

DO WHILE .T.
SET COLOR TO GR+/B+
   * ---Display menu options, centered on the screen.
   *    draw menu border and print heading
   CLEAR

   @ 2, 0 TO 12,79 DOUBLE
   @ 3,24 SAY [B R O W S E   F I L E S   M E N U]
   @ 4,1 TO 4,78 DOUBLE
   * ---display detail lines
   @  7,29 SAY [1. BROWSE BASIC FILES]
   @  8,29 SAY [2. BROWSE ANY FILES]
   @ 10, 29 SAY '0. EXIT'
   STORE 0 TO selectnum
   @ 12,33 SAY " select     "
   @ 12,42 GET selectnum PICTURE "9" RANGE 0,2

   READ

   DO CASE

      CASE selectnum = 0
         SET TALK ON
         CLEAR ALL
         RETURN

      CASE selectnum = 1
      *  DO BROWSE BASIC FILES
         DO BROBASIC
*        SET CONFIRM ON
*        STORE ' ' TO wait_subst
*        @ 23,0 SAY 'Press any key to continue...' GET wait_subst
*        READ
*        SET CONFIRM OFF
```

```
       CASE selectnum = 2
       *  DO BROWSE ANY FILES
          DO BROAANY
*         SET CONFIRM OFF
*         STORE ' ' TO wait_subst
*         @ 23,0 SAY 'Press any key to continue...' GET wait_subst
*         READ
*         SET CONFIRM ON

ENDCASE

ENDDO T

RETURN

* EOF: BROWMENU.PRG

^Z
```

```
* Program..: CQUERYMENU.PRG
* Author...: TUNG'S TIGERS
* Purpose..: Allows user to create ad hoc queries.
* Date.....: 12/06/86
* I/O Files: ANY SELECTED BY USER
* Called By: TIGER.PRG
* Calls Mod: PRINT.PRG
* Reserved.: selectnum
* Variables: NONE

SET TALK OFF
SET BELL OFF
SET STATUS ON
SET ESCAPE ON
SET CONFIRM OFF

DO WHILE .T.
SET COLOR TO GR+/B+
   * ---Display menu options, centered on the screen.
   *    draw menu border and print heading
   CLEAR

   @ 2, 0 TO 12,79 DOUBLE
   @ 3,24 SAY [C R E A T E   Q U E R Y   M E N U]
   @ 4,1 TO 4,78 DOUBLE
   * ---display detail lines
   @  7,31 SAY [1. CREATE NEW QUERY]
   @  8,31 SAY [2. LIST QUERY FILES]
   @ 10, 31 SAY '0. EXIT'
   STORE 0 TO selectnum
   @ 12,33 SAY " select     "
   @ 12,42 GET selectnum PICTURE "9" RANGE 0,2

   READ

   DO CASE

      CASE selectnum = 0
         SET TALK ON
         CLEAR ALL
         RETURN

      CASE selectnum = 1
      *  DO CREATE NEW QUERY
         CREATE QUERY
*        SET CONFIRM OFF
*        STORE ' ' TO wait_subst
*        @ 23,0 SAY 'Press any key to continue...' GET wait_subst
*         READ
*         SET CONFIRM ON
```

```
      CASE selectnum = 2
      *  DO LIST QUERY FILES
         DO PRINT
         DIR *.QRY
         SET PRINT OFF
         SET CONFIRM OFF
         STORE ' ' TO wait_subst
         @ 23,0 SAY 'Press any key to continue...' GET wait_subst
         READ
         SET CONFIRM ON

ENDCASE

ENDDO T

RETURN

* EOF: CQUERYMENU.PRG

^Z
```

```
* Program..: CREPORTMENU.PRG
* Author...: TUNG'S TIGERS
* Purpose..: Allows user to create ad hoc reports.
* Date.....: 12/06/86
* I/O Files: ANY SELECTED BY USER
* Called By: TIGER.PRG
* Calls Mod: PRINT.PRG
* Reserved.: selectnum
* Variables: NONE

SET TALK OFF
SET BELL OFF
SET STATUS ON
SET ESCAPE ON
SET CONFIRM OFF

DO WHILE .T.
SET COLOR TO GR+/B+
   * ---Display menu options, centered on the screen.
   *    draw menu border and print heading
   CLEAR

   @ 2, 0 TO 12,79 DOUBLE
   @ 3,23 SAY [C R E A T E   R E P O R T   M E N U]
   @ 4,1 TO 4,78 DOUBLE
   * ---display detail lines
   @  7,26 SAY [1. CREATE NEW REPORT]
   @  8,26 SAY [2. LIST EXISTING REPORT FILES]
   @ 10, 26 SAY '0. EXIT'
   STORE 0 TO selectnum
   @ 12,33 SAY " select     "
   @ 12,42 GET selectnum PICTURE "9" RANGE 0,2
   READ

   DO CASE

      CASE selectnum = 0
         SET TALK ON
         CLEAR ALL
         RETURN

      CASE selectnum = 1
      *   DO CREATE NEW REPORT
         CREATE REPORT
*        SET CONFIRM OFF
*        STORE ' ' TO wait_subst
*        @ 23,0 SAY 'Press any key to continue...' GET Wait_subst
*        READ
*        SET CONFIRM ON
```

```
      CASE selectnum = 2
      *   DO LIST EXISTING REPORT FILES
         DO PRINT
         DIR *.FRM
         SET PRINT OFF
         SET CONFIRM OFF
         STORE ' ' TO wait_subst
         @ 23,0 SAY 'Press any key to continue...' GET wait_subst
         READ
         SET CONFIRM ON

ENDCASE

ENDDO T

RETURN

* EOF: CREPORTMENU.PRG

^Z
```

```
* Program..: DELREC.PRG
* Author...: TUNG'S TIGERS
* Purpose..: Allows user to delete records from nine basic files.
* Date.....: 12/05/86
* I/O Files: The nine basic files.
* Called By: TIGER.PRG, MODREC.PRG
* Calls Mod: NONE
* Reserved.: selectnum
* Variables: DEMODEL, WAITPACK

SET TALK OFF
SET BELL ON
SET STATUS ON
SET ESCAPE ON
SET CONFIRM ON

DO WHILE .T.
SET COLOR TO W+/R+,GR+/B+,R+
   * ---Display menu options, centered on the screen.
   *    draw menu border and print heading

   CLEAR

        STORE " " TO DELETEMODEL
        ACCEPT "ENTER AIRCRAFT MODEL ..." TO DELETEMODEL

        USE AIRCRAFT
        DELETE FOR MODEL=DELETEMODEL
        STORE " " TO WAITPACK
        SET COLOR TO GR+/R+
        WAIT [DELETE MARKED AIRCRAFT RECORDS? (Y/N)] TO WAITPACK
        IF UPPER(WAITPACK)="Y"
              PACK
        ELSE RECALL ALL
        ENDIF

        USE CHAR
        DELETE FOR MODEL=DELETEMODEL
        STORE " " TO WAITPACK
        WAIT [DELETE MARKED CHARACTER RECORDS? (Y/N)] TO WAITPACK
        IF UPPER(WAITPACK)="Y"
              PACK
        ELSE RECALL ALL
        ENDIF

        USE PERFORMA
        DELETE FOR MODEL=DELETEMODEL
        STORE " " TO WAITPACK
        WAIT [DELETE MARKED PERFORMANCE RECORDS? (Y/N)] TO
       WAITPACK
        IF UPPER(WAITPACK)="Y"
              PACK
        ELSE RECALL ALL
        ENDIF
```

```
USE RATIOS
DELETE FOR MODEL=DELETEMODEL
STORE " " TO WAITPACK
WAIT [DELETE MARKED RATIOS RECORDS? (Y/N)] TO WAITPACK
IF UPPER(WAITPACK)="Y"
      PACK
ELSE RECALL ALL
ENDIF

USE WEIGHT
DELETE FOR MODEL=DELETEMODEL
STORE " " TO WAITPACK
WAIT [DELETE MARKED WEIGHT RECORDS? (Y/N)] TO WAITPACK
IF UPPER(WAITPACK)="Y"
      PACK
ELSE RECALL ALL
ENDIF

USE FATIGUE
DELETE FOR MODEL=DELETEMODEL
STORE " " TO WAITPACK
WAIT [DELETE MARKED FATIGUE RECORDS? (Y/N)] TO WAITPACK
IF UPPER(WAITPACK)="Y"
      PACK
ELSE RECALL ALL
ENDIF

USE FLIGHT
DELETE FOR MODEL=DELETEMODEL
STORE " " TO WAITPACK
WAIT [DELETE MARKED FLIGHT RECORDS? (Y/N)] TO WAITPACK
IF UPPER(WAITPACK)="Y"
      PACK
ELSE RECALL ALL
ENDIF

USE STATIC
DELETE FOR MODEL=DELETEMODEL
STORE " " TO WAITPACK
WAIT [DELETE MARKED STATIC RECORDS? (Y/N)] TO WAITPACK
IF UPPER(WAITPACK)="Y"
      PACK
ELSE RECALL ALL
ENDIF

USE WIND
DELETE FOR MODEL=DELETEMODEL
STORE " " TO WAITPACK
WAIT [DELETE MARKED WIND RECORDS? (Y/N)] TO WAITPACK
IF UPPER(WAITPACK)="Y"
      PACK
ELSE RECALL ALL
ENDIF
```

```
*          SET CONFIRM OFF
*          STORE ' ' TO wait_subst
*          @ 23,0 SAY "Press any key to continue..." GET wait_subst
*          READ
*          SET CONFIRM ON

CLEAR

RETURN

ENDDO T

* EOF: DELREC.PRG

^Z
```

```
* Program..: DELRMENU.PRG
* Author...: TUNG'S TIGERS
* Purpose..: Caution user concerning permanently deleting records
* Date.....: 02/20/87
* I/O Files: NONE
* Called By: TIGER.PRG, MODMENU.PRG
* Calls Mod: DELREC.PRG
* Reserved.: selectnum

SET TALK OFF
SET BELL OFF
SET STATUS ON
SET ESCAPE ON
SET CONFIRM OFF

DO WHILE .T.
SET COLOR TO GR+/B+,GR+/R+,R+
   * ---Display menu options, centered on the screen.
   *    draw menu border and print heading
   CLEAR
   @ 2, 0 TO 11,79 DOUBLE
   @ 3,27 SAY [D E L E T E   R E C O R D S]
   @ 4,1 TO 4,78 DOUBLE
   * ---display detail lines
   @  7, 7 SAY [1. YOU ARE ABOUT TO PERMANENTLY DELETE SELECTED]
   @  7, 55 SAY [RECORDS FROM FILES]
   @  9,  7 SAY '0. EXIT'
   STORE 0 TO selectnum
   @ 11,33 SAY " select     "
   @ 11,42 GET selectnum PICTURE "9" RANGE 0,1
   READ

   DO CASE
      CASE selectnum = 0
         SET BELL ON
         SET TALK ON
         CLEAR ALL
         SET COLOR TO GR+/B+,GR+/R+,BG+
         RETURN

      CASE selectnum = 1
      *   DO YOU ARE ABOUT TO PERMANENTLY DELETE SELECTED RECORDS
      *   FROM FILES
         DO DELREC
*        @ 23,0 SAY 'Press any key to continue...' GET wait_subst
*        READ
*        SET CONFIRM ON

ENDCASE
ENDDO T
SET COLOR TO GR+/B+,GR+/R+,BG+
RETURN
* EOF: DELRMENU.PRG

^Z
```

```
* Program..: EDITREC.PRG
* Author...: TUNG'S TIGERS
* Purpose..: Allows user to edit the nine basic files.
* Date.....: 12/05/86
* I/O Files: AIRCRAFT.DBF, CHAR.DBF, FATIGUE.DBF, FLIGHT.DBF,
*             PERFORMA.DBF, RATIOS.DBF, STATIC.DBF, WEIGHT.DBF,
*            WIND.DBF
* Called By: TIGER.PRG, MODMENU.PRG
* Calls Mod: NONE
* Reserved.: selectnum
* Variables: NONE

SET TALK OFF
SET BELL OFF
SET STATUS ON
SET ESCAPE ON
SET CONFIRM OFF

DO WHILE .T.
SET COLOR TO GR+/B+
   * ---Display menu options, centered on the screen.
   *    draw menu border and print heading

   CLEAR
   @ 2, 0 TO 19,79 DOUBLE
   @ 3,25 SAY [E D I T  R E C O R D S  M E N U]
   @ 4,1 TO 4,78 DOUBLE
   * ---display detail lines
   @  7,31 SAY [1. AIRCRAFT]
   @  8,31 SAY [2. CHARACTERISTICS]
   @  9,31 SAY [3. PERFORMANCE]
   @ 10,31 SAY [4. RATIOS/FACTORS]
   @ 11,31 SAY [5. WEIGHT]
   @ 12,31 SAY [6. FATIGUE TEST]
   @ 13,31 SAY [7. FLIGHT TEST]
   @ 14,31 SAY [8. STATIC TEST]
   @ 15,31 SAY [9. WIND TUNNEL TEST]
   @ 17, 31 SAY '0. EXIT'
   STORE 0 TO selectnum
   @ 19,33 SAY " select     "
   @ 19,42 GET selectnum PICTURE "9" RANGE 0,9
   READ

   DO CASE

      CASE selectnum = 0
         SET TALK OFF
         CLEAR ALL
         RETURN
      CASE selectnum = 1
      *  DO AIRCRAFT
         USE AIRCRAFT
         EDIT
*        SET CONFIRM OFF
*        STORE ' ' TO wait_subst
*        @ 23,0 SAY 'Press any key to continue...' GET wait_subst
*        READ
*        SET CONFIRM ON

      CASE selectnum = 2
      *  DO CHARACTERISTICS
         USE CHAR
         EDIT
*        SET CONFIRM OFF
*        STORE ' ' TO wait_subst
*        @ 23,0 SAY 'Press any key to continue...' GET wait_subst
*        READ
*        SET CONFIRM ON

      CASE selectnum = 3
      *  DO PERFORMANCE
         USE PERFORMA
         EDIT
*        SET CONFIRM OFF
*        STORE ' ' TO wait_subst
*        @ 23,0 SAY 'Press any key to continue...' GET wait_subst
*        READ
*        SET CONFIRM ON

      CASE selectnum = 4
      *  DO RATIOS/FACTORS
         USE RATIOS
         EDIT
*        SET CONFIRM OFF
*        STORE ' ' TO wait_subst
*        @ 23,0 SAY 'Press any key to continue...' GET wait_subst
*        READ
*        SET CONFIRM ON

      CASE selectnum = 5
      *  DO WEIGHT
         USE WEIGHT
         EDIT
*        SET CONFIRM OFF
*        STORE ' ' TO wait_subst
*        @ 23,0 SAY 'Press any key to continue...' GET wait_subst
*        READ
*        SET CONFIRM ON
```

```
      CASE selectnum = 6
      *   DO FATIGUE TEST
          USE FATIGUE
          EDIT
*         SET CONFIRM OFF
*         STORE ' ' TO wait_subst
*         @ 23,0 SAY 'Press any key to continue...' GET wait_subst
*         READ
*         SET CONFIRM ON

      CASE selectnum = 7
      *   DO FLIGHT TEST
          USE FLIGHT
          EDIT
*         SET CONFIRM OFF
*         STORE ' ' TO wait_subst
*         @ 23,0 SAY 'Press any key to continue...' GET wait_subst
*         READ
*         SET CONFIRM ON

      CASE selectnum = 8
      *   DO STATIC TEST
          USE STATIC
          EDIT
*         SET CONFIRM OFF
*         STORE ' ' TO wait_subst
*         @ 23,0 SAY 'Press any key to continue...' GET wait_subst
*         READ
*         SET CONFIRM ON

      CASE selectnum = 9
      *   DO WIND TUNNEL TEST
          USE WIND
          EDIT
*         SET CONFIRM OFF
*         STORE ' ' TO wait_subst
*         @ 23,0 SAY 'Press any key to continue...' GET wait_subst
*         READ
*         SET CONFIRM ON

ENDCASE

ENDDO T

RETURN

* EOF: EDITREC.PRG

^Z
```

```
* Program..: JOINFILE.PRG
* Author...: TUNG'S TIGERS
* Purpcse..: Allows user to join selected files.
* Date.....: 12/05/86
* I/O Files: Files as selected by user.
* Called By: TIGER.PRG
* Calls Mod: PRINT.PRG
* Reserved.: selectnum
* Variables: FILEONE, FILETWO, NEWFILE

SET TALK OFF
SET BELL OFF
SET STATUS ON
SET ESCAPE ON
SET CONFIRM OFF

DO WHILE .T.
SET COLOR TO GR+/B+
   * ---Display menu options, centered on the screen.
   *    draw menu border and print heading
   CLEAR
   @ 2, 0 TO 13,79 DOUBLE
   @ 3,26 SAY [J O I N   F I L E S   M E N U]
   @ 4,1 TO 4,78 DOUBLE
   * ---display detail lines
   @  7,29 SAY [1. LIST EXISTING FILES]
   @  8,29 SAY [2. JOIN FILES]
   @  9,29 SAY [3. JOIN TO FORM SPECS]
   @ 11, 29 SAY '0. EXIT'
   STORE 0 TO selectnum
   @ 13,33 SAY " select     "
   @ 13,42 GET selectnum PICTURE "9" RANGE 0,3
   READ

   DO CASE
      CASE selectnum = 0
         SET TALK ON
         CLEAR ALL
         RETURN

      CASE selectnum = 1
      *  DO LIST EXISTING FILES
         DO PRINT
         DIR *.DBF
         SET PRINT OFF
         SET CONFIRM OFF
         STORE ' ' TO wait_subst
         @ 23,0 SAY 'Press any key to continue...' GET wait_subst
         READ
         SET CONFIRM ON
```

```
CASE selectnum = 2
*   DO JOIN FILES
   ACCEPT [Enter filename 1...] TO FILEONE
   ACCEPT [Enter filename 2...] TO FILETWO
   ACCEPT [Enter new filename...]  TO NEWFILE
   SELECT A
   USE &FILEONE
   SELECT B
   USE &FILETWO
   JOIN WITH &FILEONE TO &NEWFILE FOR MODEL=A->MODEL

CASE selectnum = 3
* DO JOIN TO FORM SPECS

    SELECT A
    USE CHAR
    SELECT B
    USE AIRCRAFT
    JOIN WITH CHAR TO TJOIN1 FOR MODEL=A->MODEL

    SELECT A
    USE PERFORMA
    SELECT B
    USE TJOIN1
    JOIN WITH PERFORMA TO TJOIN2 FOR MODEL=A->MODEL

    SELECT A
    USE RATIOS
    SELECT B
    USE TJOIN2
    JOIN WITH RATIOS TO TJOIN3 FOR MODEL=A->MODEL

    SELECT A
    USE WEIGHT
    SELECT B
    USE TJOIN3
    JOIN WITH WEIGHT TO TJOIN4 FOR MODEL=A->MODEL

    SELECT A
    USE FATIGUE
    SELECT B
    USE TJOIN4
    JOIN WITH FATIGUE TO TJOIN5 FOR MODEL=A->MODEL

    SELECT A
    USE FLIGHT
    SELECT B
    USE TJOIN5
    JOIN WITH FLIGHT TO TJOIN6 FOR MODEL=A->MODEL
```

```
          SELECT A
          USE STATIC
          SELECT B
          USE TJOIN6
          JOIN WITH STATIC TO TJOIN7 FOR MODEL=A->MODEL

          ERASE SPECS.DBF
          SELECT A
          USE WIND
          SELECT B
          USE TJOIN7
          JOIN WITH WIND TO SPECS FOR MODEL=A->MODEL

          CLOSE ALL

          ERASE TJOIN1.DBF
          ERASE TJOIN2.DBF
          ERASE TJOIN3.DBF
          ERASE TJOIN4.DBF
          ERASE TJOIN5.DBF
          ERASE TJOIN6.DBF
          ERASE TJOIN7.DBF


*         SET CONFIRM OFF
*         STORE ' ' TO wait_subst
*         @ 23,0 SAY 'Press any key to continue...' GET wait_subst
*         READ
*         SET CONFIRM ON
*         SET STATUS ON

ENDCASE

ENDDO T

RETURN

* EOF: JOINFILE.PRG

^Z
```

```
* Program..: LISANY.PRG
* Author...: TUNG'S TIGERS
* Purpose..: Allows user to view any selected file's structure.
* Date.....: 01/01/80
* I/O Files: Any files selected by user.
* Called By: TIGER.PRG, LISTMENU.PRG
* Calls Mod: PRINT.PRG
* Reserved.: selectnum
* Variables: LISTNAME

SET TALK OFF
SET BELL OFF
SET STATUS ON
SET ESCAPE ON
SET CONFIRM OFF

DO WHILE .T.
SET COLOR TO GR+/B+
   * ---Display menu options, centered on the screen.
   *    draw menu border and print heading
   CLEAR
   @ 2, 0 TO 12,79 DOUBLE
   @ 3,18 SAY [L I S T   A N Y   S T R U C T U R E   M E N U]
   @ 4,1 TO 4,78 DOUBLE
   * ---display detail lines
   @  7,30 SAY [1. DISPLAY STRUCTURES]
   @  8,30 SAY [2. LIST FILES]
   @ 10, 30 SAY '0. EXIT'
   STORE 0 TO selectnum
   @ 12,33 SAY " select     "
   @ 12,42 GET selectnum PICTURE "9" RANGE 0,2
   READ

   DO CASE

      CASE selectnum = 0
         SET TALK ON
         CLEAR ALL
         RETURN

      CASE selectnum = 1
      *  DO DISPLAY STRUCTURES
         ACCEPT [Enter filename...] TO LISTNAME
         USE &LISTNAME
         DO PRINT
         DISPLAY STRUCTURE
         SET CONFIRM ON
         STORE ' ' TO wait_subst
         @ 23,0 SAY 'Press any key to continue...' GET wait_subst
         READ
         SET CONFIRM ON
      CASE selectnum = 2
      *   DO LIST FILES
         DO PRINT
         DIR *.DBF
         SET PRINT OFF
         SET CONFIRM ON
         STORE ' ' TO wait_subst
         @ 23,0 SAY 'Press any key to continue...' GET wait_subst
         READ
         SET CONFIRM OFF

ENDCASE

ENDDO T

RETURN

* EOF: LISANY.PRG

^Z
```

```
* Program..: LISBASIC.PRG
* Author...: TUNG'S TIGERS
* Purpose..: Allows user to view the structure of the basic files
* Date.....: 12/06/86
* I/O Files: The nine basic database files.
* Called By: TIGER.PRG, LISTMENU.PRG
* Calls Mod: PRINT.PRG
* Reserved.: selectnum
* Variables: NONE

SET TALK OFF
SET BELL OFF
SET STATUS ON
SET ESCAPE ON
SET CONFIRM OFF

DO WHILE .T.
SET COLOR TO GR+/B+
   * ---Display menu options, centered on the screen.
   *    draw menu border and print heading
   CLEAR
   @ 2, 0 TO 19,79 DOUBLE
   @ 3,15 SAY [L I S T   B A S I C   S T R U C T U R E   M E N U]
   @ 4,1 TO 4,78 DOUBLE
   * ---display detail lines
   @  7,31 SAY [1. AIRCRAFT]
   @  8,31 SAY [2. CHARACTERISTICS]
   @  9,31 SAY [3. PERFORMANCE]
   @ 10,31 SAY [4. RATIOS/FACTORS]
   @ 11,31 SAY [5. WEIGHT]
   @ 12,31 SAY [6. FATIGUE TEST]
   @ 13,31 SAY [7. FLIGHT TEST]
   @ 14,31 SAY [8. STATIC TEST]
   @ 15,31 SAY [9. WIND TUNNEL TEST]
   @ 17, 31 SAY '0. EXIT'
   STORE 0 TO selectnum
   @ 19,33 SAY " select     "
   @ 19,42 GET selectnum PICTURE "9" RANGE 0,9
   READ

   DO CASE

      CASE selectnum = 0
         SET TALK ON
         CLEAR ALL
         RETURN
```

```
CASE selectnum = 1
*   DO AIRCRAFT
    USE AIRCRAFT
    DO PRINT
    LIST STRUCTURE
    SET PRINT OFF
    SET CONFIRM OFF
    STORE ' ' TO wait_subst
    @ 23,0 SAY 'Press any key to continue...' GET wait_subst
    READ
    SET CONFIRM ON

CASE selectnum = 2
*   DO CHARACTERISTICS
    USE CHAR
    DO PRINT
    LIST STRUCTURE
    SET PRINT OFF
    SET CONFIRM OFF
    STORE ' ' TO wait_subst
    @ 23,0 SAY 'Press any key to continue...' GET wait_subst
    READ
    SET CONFIRM ON

CASE selectnum = 3
*   DO PERFORMANCE
    USE PERFORMA
    DO PRINT
    LIST STRUCTURE
    SET PRINT OFF
    SET CONFIRM OFF
    STORE ' ' TO wait_subst
    @ 23,0 SAY 'Press any key to continue...' GET wait_subst
    READ
    SET CONFIRM ON

CASE selectnum = 4
*   DO RATIOS/FACTORS
    USE RATIOS
    DO PRINT
    LIST STRUCTURE
    SET PRINT OFF
    SET CONFIRM OFF
    STORE ' ' TO wait_subst
    @ 23,0 SAY 'Press any key to continue...' GET wait_subst
    READ
    SET CONFIRM ON
```

```
CASE selectnum = 5
*   DO WEIGHT
    USE WEIGHT
    DO PRINT
    LIST STRUCTURE
    SET PRINT OFF
    SET CONFIRM OFF
    STORE ' ' TO wait_subst
    @ 23,0 SAY 'Press any key to continue...' GET wait_subst
    READ
    SET CONFIRM ON

CASE selectnum = 6
*   DO FATIGUE TEST
    USE FATIGUE
    DO PRINT
    LIST STRUCTURE
    SET PRINT OFF
    SET CONFIRM OFF
    STORE ' ' TO wait_subst
    @ 23,0 SAY 'Press any key to continue...' GET wait_subst
    READ
    SET CONFIRM ON

CASE selectnum = 7
*   DO FLIGHT TEST
    USE FLIGHT
    DO PRINT
    LIST STRUCTURE
    SET PRINT OFF
    SET CONFIRM OFF
    STORE ' ' TO wait_subst
    @ 23,0 SAY 'Press any key to continue...' GET wait_subst
    READ
    SET CONFIRM ON

CASE selectnum = 8
*   DO STATIC TEST
    USE STATIC
    DO PRINT
    LIST STRUCTURE
    SET PRINT OFF
    SET CONFIRM OFF
    STORE ' ' TO wait_subst
    @ 23,0 SAY 'Press any key to continue...' GET wait_subst
    READ
    SET CONFIRM ON
```

```
      CASE selectnum = 9
      *   DO WIND TUNNEL TEST
          USE WIND
          DO PRINT
          LIST STRUCTURE
          SET PRINT OFF
          SET CONFIRM OFF
          STORE ' ' TO wait_subst
          @ 23,0 SAY 'Press any key to continue...' GET wait_subst
          READ
          SET CONFIRM ON

ENDCASE

ENDDO T

RETURN

* EOF: LISBASIC.PRG

^Z
```

```
* Program..: LISTMENU.PRG
* Author...: TUNG'S TIGERS
* Purpose..: Allows user to view a file's structure.
* Date.....: 01/01/80
* I/O Files: NONE
* Called By: TIGER.PRG
* Calls Mod: LISBASIC.PRG, LISANY.PRG
* Reserved.: selectnum
* Variables: NONE

SET TALK OFF
SET BELL OFF
SET STATUS ON
SET ESCAPE ON
SET CONFIRM OFF

DO WHILE .T.
SET COLOR TO GR+/B+
   * ---Display menu options, centered on the screen.
   *    draw menu border and print heading
   CLEAR
   @ 2, 0 TO 12,79 DOUBLE
   @ 3,22 SAY [L I S T   S T R U C T U R E   M E N U]
   @ 4,1 TO 4,78 DOUBLE
   * ---display detail lines
   @  7,30 SAY [1. LIST BASIC STRUCTURES]
   @  8,30 SAY [2. LIST ANY STRUCTURE]
   @ 10, 30 SAY '0. EXIT'
   STORE 0 TO selectnum
   @ 12,33 SAY " select     "
   @ 12,42 GET selectnum PICTURE "9" RANGE 0,2
   READ

   DO CASE

      CASE selectnum = 0
         SET TALK ON
         CLEAR ALL
         RETURN

      CASE selectnum = 1
      *  DO LIST BASIC STRUCTURES
         DO LISBASIC
*        SET CONFIRM OFF
*        STORE ' ' TO wait_subst
*        @ 23,0 SAY 'Press any key to continue...' GET wait_subst
*        READ
*        SET CONFIRM ON
```

```
      CASE selectnum = 2
      *   DO LIST ANY STRUCTURE
          DO LISANY
*         SET CONFIRM OFF
*         STORE ' ' TO wait_subst
*         @ 23,0 SAY 'Press any key to continue...' GET wait_subst
*         READ
*         SET CONFIRM ON

ENDCASE

ENDDO T

RETURN

* EOF: LISTMENU.PRG

^Z
```

```
* Program..: MODMENU.PRG
* Author...: TUN'S TIGERS
* Purpose..: Allows user to select type of record modifcation.
* Date.....: 02/18/87
* I/O Files: NONE
* Called By: TIGER.PRG
* Calls Mod: ADDMOD.PRG, EDITREC.PRG, DELRMENU.PRG
* Reserved.: selectnum
* Variables:

SET TALK OFF
SET BELL OFF
SET STATUS ON
SET ESCAPE OFF
SET CONFIRM OFF

DO WHILE .T.
SET COLOR TO GR+/B+
   * ---Display menu options, centered on the screen.
   *    draw menu border and print heading
   CLEAR
   @ 2, 0 TO 13,79 DOUBLE
   @ 3,23 SAY [M O D I F Y  R E C O R D S  M E N U]
   @ 4,1 TO 4,78 DOUBLE
   * ---display detail lines
   @  7,33 SAY [1. ADD AIRCRAFT MODEL]
   @  8,33 SAY [2. EDIT RECORDS]
   @  9,33 SAY [3. DELETE RECORDS]
   @ 11, 33 SAY '0. EXIT'
   STORE 0 TO selectnum
   @ 13,33 SAY " select     "
   @ 13,42 GET selectnum PICTURE "9" RANGE 0,3
   READ

   DO CASE

      CASE selectnum = 0
         SET BELL ON
         SET TALK ON
         CLEAR ALL
         RETURN

      CASE selectnum = 1
      *  DO ADD AIRCRAFT MODEL
         DO ADDMOD
         SET CONFIRM OFF
         STORE ' ' TO wait_subst
         @ 23,0 SAY 'Press any key to continue...' GET wait_subst
         READ
         SET CONFIRM ON
      CASE selectnum = 2
      *  DO EDIT RECORDS
         DO EDITREC
         SET CONFIRM OFF
         STORE ' ' TO wait_subst
         @ 23,0 SAY 'Press any key to continue...' GET wait_subst
         READ
         SET CONFIRM ON

      CASE selectnum = 3
      *  DO DELETE RECORDS
         DO DELRMENU
         SET CONFIRM OFF
         STORE ' ' TO wait_subst
         @ 23,0 SAY 'Press any key to continue...' GET wait_subst
         READ
         SET CONFIRM ON

ENDCASE

ENDDO T

RETURN

* EOF: MODMENU.PRG

^Z
```

```
* Program..: PRINT.PRG
* Author...: TUNG'S TIGERS
* Purpose..: Allows user to send output to printer if desired.
* Date.....: 12/06/86
* I/O Files: NONE
* Called By: BROWANY.PRG, CQUERYMENU.PRG, CREPORTMENU.PRG,
*            JOINFILE.PRG, LISBASIC.PRG, LISANY.PRG,
*            PRINTANY.PRG, PRINTBASIC.PRG
* Calls Mod: NONE
* Reserved.: selectnum
* Variables: ANSWER

SET TALK OFF
SET BELL OFF
SET STATUS ON
SET ESCAPE ON
SET ECHO OFF

* Select output media

STORE " " TO ANSWER
WAIT  [Direct the output to the printer? (Y/N)] TO ANSWER

IF UPPER(ANSWER)="Y"
    SET PRINT ON
    RETURN
ELSE
    RETURN
ENDIF

* EOF:  PRINT.PRG

^Z
```

```
* Program..: PRINTANY.PRG
* Author...: TUNG'S TIGERS
* Purpose..: Allows the user to print any report.
* Date.....: 02/19/87
* I/O Files: ANY REPORT FILES SELECTED BY USER
* Called By: TIGER.PRG, PRPTMENU.PRG
* Calls Mod: PRINT.PRG
* Reserved.: selectnum
* Variables:

SET TALK OFF
SET BELL OFF
SET STATUS ON
SET ESCAPE OFF
SET CONFIRM OFF

DO WHILE .T.
SET COLOR TO GR+/B+
   * ---Display menu options, centered on the screen.
   *    draw menu border and print heading
   CLEAR
   @ 2, 0 TO 12,79 DOUBLE
   @ 3,20 SAY [P R I N T   A N Y   R E P O R T   M E N U]
   @ 4,1 TO 4,78 DOUBLE
   * ---display detail lines
   @  7,33 SAY [1. PRINT ANY REPORT]
   @  8,33 SAY [2. LIST REPORTS]
   @ 10, 33 SAY '0. EXIT'
   STORE 0 TO selectnum
   @ 12,33 SAY " select     "
   @ 12,42 GET selectnum PICTURE "9" RANGE 0,2
   READ

   DO CASE

      CASE selectnum = 0
         SET BELL ON
         SET TALK ON
         CLEAR ALL
         RETURN

      CASE selectnum = 1
      *  DO PRINT ANY REPORT
         ACCEPT [Enter DBF filename...] TO DBFFILE
         ACCEPT [Enter Report Name....] TO RPTFILE
         USE &DBFFILE
         DO PRINT
         REPORT FORM &RPTFILE
         SET PRINTER OFF
         SET CONFIRM OFF
         STORE ' ' TO wait_subst
         @ 23,0 SAY 'Press any key to continue...' GET wait_subst
         READ
         SET CONFIRM ON
      CASE selectnum = 2
      *  DO LIST REPORTS
         DO PRINT
         DIR *.FRM
         SET PRINT OFF
         SET CONFIRM OFF
         STORE ' ' TO wait_subst
         @ 23,0 SAY 'Press any key to continue...' GET wait_subst
         READ
         SET CONFIRM ON

ENDCASE

ENDDO T

RETURN

* EOF: PRINTANY.PRG

^Z
```

```
* Program..: PRINTBASIC.PRG
* Author...: TUNG'S TIGERS
* Purpose..: Allows the user to print any report available.
* Date.....: 02/19/87
* I/O Files: AIRCRAFT.DBF, CHAR.DBF, PERFORMA.DBF, RATIOS.DBF,
*            WEIGHT.DBF, FATIGUE.DBF, FLIGHT.DBF, STATIC.DBF,
*            WIND.DBF
* Called By: TIGER.PRG, PRPTMENU.PRG
* Calls Mod: PRINT.PRG
* Reserved.: selectnum
* Variables:

SET TALK OFF
SET BELL OFF
SET STATUS ON
SET ESCAPE OFF
SET CONFIRM OFF

DO WHILE .T.
SET COLOR TO GR+/B+
   * ---Display menu options, centered on the screen.
   *    draw menu border and print heading
   CLEAR
   @ 2, 0 TO 19,79 DOUBLE
   @ 3,18 SAY [P R I N T   B A S I C   R E P O R T   M E N U]
   @ 4,1 TO 4,78 DOUBLE
   * ---display detail lines
   @  7,31 SAY [1. AIRCRAFT]
   @  8,31 SAY [2. CHARACTERISTICS]
   @  9,31 SAY [3. PERFORMANCE]
   @ 10,31 SAY [4. RATIOS/FACTORS]
   @ 11,31 SAY [5. WEIGHT]
   @ 12,31 SAY [6. FATIGUE TEST]
   @ 13,31 SAY [7. FLIGHT TEST]
   @ 14,31 SAY [8. STATIC TEST]
   @ 15,31 SAY [9. WIND TEST]
   @ 17,31 SAY '0. EXIT'
   STORE 0 TO selectnum
   @ 19,33 SAY " select    "
   @ 19,42 GET selectnum PICTURE "9" RANGE 0,9
   READ

   DO CASE

      CASE selectnum = 0
         SET BELL ON
         SET TALK ON
         CLEAR ALL
         RETURN
```

```
CASE selectnum = 1
*   DO AIRCRAFT
    USE AIRCRAFT
    DO PRINT
    REPORT FORM AIRRPT.FRM
    SET PRINT OFF
    SET CONFIRM OFF
    STORE ' ' TO wait_subst
    @ 23,0 SAY 'Press any key to continue...' GET wait_subst
    READ
    SET CONFIRM ON

CASE selectnum = 2
*   DO CHAR
    USE CHAR
    DO PRINT
    REPORT FORM CHARPT.FRM
    SET PRINT OFF
    SET CONFIRM OFF
    STORE ' ' TO wait_subst
    @ 23,0 SAY 'Press any key to continue...' GET wait_subst
    READ
    SET CONFIRM ON

CASE selectnum = 3
*   DO PERFORMANCE
    USE PERFORMA
    DO PRINT
    REPORT FORM PERRPT.FRM
    SET PRINT OFF
    SET CONFIRM OFF
    STORE ' ' TO wait_subst
    @ 23,0 SAY 'Press any key to continue...' GET wait_subst
    READ
    SET CONFIRM ON

CASE selectnum = 4
*   DO RATIOS
    USE RATIOS
    DO PRINT
    REPORT FORM RATRPT.FRM
    SET PRINT OFF
    SET CONFIRM OFF
    STORE ' ' TO wait_subst
    @ 23,0 SAY 'Press any key to continue...' GET wait_subst
    READ
    SET CONFIRM ON
```

```
CASE selectnum = 5
*   DO WEIGHT
    USE WEIGHT
    DO PRINT
    REPORT FORM WGTRPT.FRM
    SET PRINT OFF
    SET CONFIRM OFF
    STORE ' ' TO wait_subst
    @ 23,0 SAY 'Press any key to continue...' GET wait_subst
    READ
    SET CONFIRM ON

CASE selectnum = 6
*   DO FATIGUE
    USE FATIGUE
    DO PRINT
    REPORT FORM FATRPT.FRM
    SET PRINT OFF
    SET CONFIRM OFF
    STORE ' ' TO wait_subst
    @ 23,0 SAY 'Press any key to continue...' GET wait_subst
    READ
    SET CONFIRM ON

CASE selectnum = 7
*   DO FLIGHT
    USE FLIGHT
    DO PRINT
    REPORT FORM FLTRPT.FRM
    SET PRINT OFF
    SET CONFIRM OFF
    STORE ' ' TO wait_subst
    @ 23,0 SAY 'Press any key to continue...' GET wait_subst
    READ
    SET CONFIRM ON

CASE selectnum = 8
*   DO STATIC
    USE STATIC
    DO PRINT
    REPORT FORM STARPT.FRM
    SET PRINT OFF
    SET CONFIRM OFF
    STORE ' ' TO wait_subst
    @ 23,0 SAY 'Press any key to continue...' GET wait_subst
    READ
    SET CONFIRM ON
```

```
      CASE selectnum = 9
      *   DO WIND
         USE WIND
         DO PRINT
         REPORT FORM WNDRPT.FRM
         SET PRINT OFF
         SET CONFIRM OFF
         STORE ' ' TO wait_subst
         @ 23,0 SAY 'Press any key to continue...' GET wait_subst
         READ
         SET CONFIRM ON

ENDCASE

ENDDO T

RETURN

* EOF: PRINTBASIC.PRG

^Z
```

```
* Program..: PRPTMENU.PRG
* Author...: TUNG'S TIGERS
* Purpose..: Allows user to print selected reports
* Date.....: 02/19/87
* I/O Files: NONE
* Called By: TIGER.PRG
* Calls Mod: PRINTBASIC.PRG, PRINTANY.PRG, PRINT.PRG
* Reserved.: selectnum
* Variables:

SET TALK OFF
SET BELL OFF
SET STATUS ON
SET ESCAPE OFF
SET CONFIRM OFF

DO WHILE .T.
SET COLOR TO GR+/B+
   * ---Display menu options, centered on the screen.
   *    draw menu border and print heading
   CLEAR
   @ 2, 0 TO 12,79 DOUBLE
   @ 3,23 SAY [P R I N T   R E P O R T S   M E N U]
   @ 4,1 TO 4,78 DOUBLE
   * ---display detail lines
   @  7,31 SAY [1. PRINT BASIC REPORTS]
   @  8,31 SAY [2. PRINT ANY REPORT]
   @ 10, 31 SAY '0. EXIT'
   STORE 0 TO selectnum
   @ 12,33 SAY " select     "
   @ 12,42 GET selectnum PICTURE "9" RANGE 0,2
   READ

   DO CASE

      CASE selectnum = 0
         SET BELL ON
         SET TALK ON
         CLEAR ALL
         RETURN

      CASE selectnum = 1
      *  DO PRINT BASIC REPORTS
         DO PRINTBASIC
*        SET CONFIRM OFF
*        STORE ' ' TO wait_subst
*        @ 23,0 SAY 'Press any key to continue...' GET wait_subst
*        READ
*        SET CONFIRM ON
```

```
     CASE selectnum = 2
      *   DO PRINT ANY REPORT
          DO PRINTANY
*         SET CONFIRM OFF
*         STORE ' ' TO wait_subst
*         @ 23,0 SAY 'Press any key to continue...' GET wait_subst
*         READ
*         SET CONFIRM ON

ENDCASE

ENDDO T

RETURN

* EOF: PRPTMENU.PRG

^Z
```

```
* Program..: TIGER.PRG
* Author...: TUNG'S TIGERS
* Date.....: 02/18/87
* Purpose..: This program assists the user in the selection of
*            actions to be performed on the database.
* I/O Files: None
* Called by: None
* Calls Mod: BROWMENU.PRG, CREPORTMENU.PRG, CQUERYMENU.PRG,
*            JOINFILE.PRG, LISTMENU.PRG, MODMENU.PRG,
*            PRINTMENU.PRG
* Reserved.: selectnum
* Variables: None

SET TALK OFF
SET BELL OFF
SET STATUS ON
SET ESCAPE ON
SET CONFIRM OFF

DO WHILE .T.
SET COLOR TO GR+/B+
   * ---Display menu options, centered on the screen.
   *    draw menu border and print heading
   CLEAR
   @ 2, 0 TO 17,79 DOUBLE
   @ 3,26 SAY [T I G E R   M A I N   M E N U]
   @ 4,1 TO 4,78 DOUBLE
   * ---display detail lines
   @  7,32 SAY [1. LIST STRUCTURES]
   @  8,32 SAY [2. BROWSE FILES]
   @  9,32 SAY [3. JOIN FILES]
   @ 10,32 SAY [4. MODIFY RECORDS]
   @ 11,32 SAY [5. CREATE REPORTS]
   @ 12,32 SAY [6. CREATE QUERIES]
   @ 13,32 SAY [7. PRINT REPORTS]
   @ 15, 32 SAY '0. EXIT'
   STORE 0 TO selectnum
   @ 17,33 SAY " select     "
   @ 17,42 GET selectnum PICTURE "9" RANGE 0,7
   READ

   DO CASE

      CASE selectnum = 0
         SET BELL ON
         SET TALK ON
         CLEAR ALL
         RETURN
      CASE selectnum = 1
      *   DO LIST STRUCTURES
          DO LISTMENU
*         SET CONFIRM OFF
*         STORE ' ' TO wait_subst
*         @ 23,0 SAY 'Press any key to continue...' GET wait_subst
*         READ
*         SET CONFIRM ON

      CASE selectnum = 2
      *   DO BROUSE FILES
          DO BROWMENU
*         SET CONFIRM OFF
*         STORE ' ' TO wait_subst
*         @ 23,0 SAY 'Press any key to continue...' GET wait_subst
*         READ
*         SET CONFIRM ON

      CASE selectnum = 3
      *   DO JOIN FILES
          DO JOINFILE
*         SET CONFIRM OFF
*         STORE ' ' TO wait_subst
*         @ 23,0 SAY 'Press any key to continue...' GET wait_subst
*         READ
*         SET CONFIRM ON

      CASE selectnum = 4
      *   DO MODIFY RECORDS
          DO MODMENU
*         SET CONFIRM OFF
*         STORE ' ' TO wait_subst
*         @ 23,0 SAY 'Press any key to continue...' GET wait_subst
*         READ
*         SET CONFIRM ON

      CASE selectnum = 5
      *   DO CREATE REPORTS
          DO CREPORTMENU
*         SET CONFIRM OFF
*         STORE ' ' TO wait_subst
*         @ 23,0 SAY 'Press any key to continue...' GET wait_subst
*         READ
*         SET CONFIRM ON

      CASE selectnum = 6
      *   DO CREATE QUERIES
          DO CQUERYMENU
*         SET CONFIRM OFF
*         STORE ' ' TO wait_subst
*         @ 23,0 SAY 'Press any key to continue...' GET wait_subst
*         READ
*         SET CONFIRM ON
```

```
      CASE selectnum = 7
      *   DO PRINT REPORTS
         DO PRPTMENU
*        SET CONFIRM OFF
*        STORE ' ' TO wait_subst
*        @ 23,0 SAY 'Press any key to continue...' GET wait_subst
*        READ
*        SET CONFIRM ON

ENDCASE

ENDDO T

SET COLOR TO W+/B+,GR+/R+, BG+

RETURN

* EOF: TIGER.PRG

^Z
```

APPENDIX C: DATA STRUCTURES

```
Structure for database: C:AIRCRAFT.dbf
Number of data records:        38
Date of last update   : 02/20/87
Field  Field Name Type       Width     Dec
    1  MODEL      Character    10
    2  MISSION    Character    10
    3  MFG        Character    20
** Total **                    41

Structure for database: C:CHAR.dbf
Number of data records:     38
Date of last update   : 02/20/87
Field  Field Name  Type      Width     Dec
    1  MODEL       Character   10
    2  CREW        Numeric      2
    3  FIRST_FLT   Numeric      5        2
    4  AWA         Numeric      4
    5  VOL         Numeric      5
    6  WL          Numeric      5        1
    7  CQ          Numeric      1
    8  AVBX        Numeric      2
    9  ENG         Numeric      1
   10  SSTA        Numeric      2
   11  THRUST      Numeric      6
** Total **                    44

Structure for database: C.PERFORMA.dbf
Number of data records:        38
Date of last update   : 02/20/87
Field  Field Name  Type      Width     Dec
    1  MODEL       Character   10
    2  VMAXA       Numeric      4
    3  VMAXS       Numeric      3
    4  VCRUISE     Numeric      3
    5  CBT_CEIL    Numeric      5
    6  SER_CEIL    Numeric      6
    7  CBT_RADIUS  Numeric      5
** Total **                    37

Structure for database: C:RATIOS.dbf
Number of data records:    38
Date of last update   : 02/20/87
Field  Field Name  Type      Width     Dec
    1  MODEL       Character   10
    2  LLF         Numeric      6        3
    3  ULF         Numeric      6        3
    4  WE/WS       Numeric      6        4
    5  WE/VOL      Numeric      7        4
    6  GTOW/WS     Numeric      6        4
** Total **                    42
```

```
Structure for database: C:WEIGHT.dbf
Number of data records:      38
Date of last update   : 02/20/87
Field  Field name  Type     Width     Dec
    1  MODEL       Character   10
    2  WS          Numeric      6
    3  WA          Numeric      6
    4  WE          Numeric      6
    5  GTOW        Numeric      6
    6  WAVU        Numeric      4
    7  WAVI        Numeric      4
    8  MAXWSS      Numeric      6
** Total **                    49

Structure for database: C:FATIGUE.dbf
Number of data records:      38
Date of lat update    : 02/20/87
Field  Field Name Type      Width     Dec
    1  MODEL      Character    10
    2  FTMOS      Numeric       3
    3  FTHRS      Numeric       6       1
    4  FENGHRS    Numeric       6       1
    5  FMFGHRS    Numeric       6       1
    6  FTOOLHR    Numeric       6       1
    7  FQCHRS     Numeric       6       1
    8  FILSHRS    Numeric       6       1
    9  FTOTHRS    Numeric       6       1
** Total **                    56

Structure for database: C:FLIGHT.dbf
Number of data records:         38
Date of last update   : 02/20/87
Field  Field Name  Type     Width     Dec
    1  MODEL       Character   10
    2  FLTHRS      Numeric      6
    3  TEVTS       Numeric      6
    4  ENGHR       Numeric      6       1
    5  MFGHR       Numeric      6       1
    6  TOOLHR      Numeric      6       1
    7  QCHR        Numeric      6       1
    8  ILSHR       Numeric      6       1
    9  TOTHRS      Numeric      6       1
** Total **                    59
```

```
Structure for database: C:STATIC.dbf
Number of data records:       38
Date of last update   : 02/20/87
Field  Field Name  Type       Width     Dec
    1  MODEL       Character     10
    2  STMOS       Numeric        3
    3  SENGHRS     Numeric        6       1
    4  SMFGHRS     Numeric        6       1
    5  STOOLHR     Numeric        6       1
    6  SQCHRS      Numeric        6       1
    7  SILSHRS     Numeric        6       1
    8  STOTHRS     Numeric        6       1
** Total **                      50

Structure for database: C:W1ND.dbf
Number of data records:       38
Date of last update   : 02/20/87
Field  Field Name  Type       Width     Dec
    1  MODEL       Character     10
    2  WTMOS       Numeric        3
    3  WTHRS       Numeric        6       1
    4  WENGHRS     Numeric        6       1
    5  WMFGHRS     Numeric        6       1
    6  WTOOLHR     Numeric        6       1
    7  WQCHRS      Numeric        6       1
    8  WILSHRS     Numeric        6       1
    9  WTOTHRS     Numeric        6       1
** Total **                      56
```

APPENDIX D: USER'S MANUAL

1. PRELIMINARY INFORMATION:

1.0 INTRODUCTION:

This User's Manual is designed to assist the NAVAIR Cost Systems, Research and Methods personnel in the use of the programs. All of the programs used are MENU DRIVEN to make this system as user friendly as possible. This manual is not designed to replace a programmer's guide.

***** This manual presupposes a basic working knowledge of dBASE III+ ASSIST functions. The three asterisks (***) symbol is used as a prompt in this manual to alert the user when the ASSIST function is required to complete the menu option.**

1.1 TIGER MAIN MENU:

Allows the user to select what basic actions are to be performed on the database. The selections are:

1. LIST STRUCTURES
2. BROWSE FILES
3. JOIN FILES
4. MODIFY RECORDS
5. CREATE REPORTS
6. CREATE QUERIES
7. PRINT REPORT

0. EXIT (to dBASE III+ ASSIST menu)

1.2 LIST STRUCTURES:

Allows the user to view the structure of a file. The selections are:

1. LIST BASIC STRUCTURES
2. LIST ANY STRUCTURE

0. EXIT (to the TIGER MAIN MENU)

1.2.1 LIST BASIC STRUCTURES:

This option allows the user to view the structure of the basic files. The selections are:

1. AIRCRAFT
2. CHARACTERISTICS
3. PERFORMANCE
4. RATIOS/FACTORS
5. WEIGHT
6. FATIGUE TEST
7. FLIGHT TEST
8. STATIC TEST
9. WIND TUNNEL TEST
0. EXIT (to the LIST STRUCTURE MENU)

1.2.2 LIST ANY STRUCTURE:

This option allows the user to view the structure of any selected file. The selections are:

1. DISPLAY STRUCTURES
2. LIST FILES
0. EXIT (to the LIST STRUCTURE MENU)

1.3 BROWSE FILES:

When the user selects this option there are three selections available:

1. BROWSE BASIC FILES
2. BROWSE ANY FILES
3. EXIT (to the TIGER MAIN MENU)

1.3.1 BROWSE BASIC FILES:

This option allows the user to view the basic data files. The selections are:

1. AIRCRAFT
2. CHARACTERISTICS
3. PERFORMANCE
4. RATIOS/FACTORS
5. WEIGHT
6. FATIGUE TEST
7. FLIGHT TEST
8. STATIC TEST
9. WIND TUNNEL TEST
0. EXIT (to the BROWSE FILES MENU)

1.3.2 BROWSE ANY FILES:

Allows the user to view the current data base files. The selections are:

1. BROWSE ANY FILE
2. LIST FILES
0. EXIT (to the BROWSE FILES MENU)

1.4 JOIN FILES:

When the user selects this option there are four selections available:

1. LIST EXISTING FILES
2. JOIN FILES
3. JOIN TO FORM SPECS
0. EXIT (to the TIGER MAIN MENU)

1.4.1 LIST EXISTING FILES:

Allows the user to view a listing of existing files.

1.4.2 JOIN FILES:

Allows the user to join files on the model field.

1.4.3 JOIN TO FORM SPECS:

Allows the user to join all the current basic files to form a specifications structure to facilitate ad hoc queries.

1.5 MODIFY RECORDS:

When the user selects this option four selections are available:

1. ADD AIRCRAFT MODEL
2. EDIT RECORDS
3. DELETE RECORDS
0. EXIT (to the TIGER MAIN MENU)

1.5.1 ADD AIRCRAFT MODEL:

This program assists the user in adding a new model aircraft to all of the nine basic files concurrently. This also does an automatic sort to place the new aircraft in alpha-numeric order.

1.5.2 EDIT RECORDS:

This program assists the user in editing records in the nine basic files. The selections are:

1. AIRCRAFT
2. CHARACTERISTICS
3. PERFORMANCE
4. RATIOS/FACTORS
5. WEIGHT
6. FATIGUE TEST
7. FLIGHT TEST
8. STATIC TEST
9. WIND TUNNEL TEST
0. EXIT (to the MODIFY RECORDS MENU)

1.5.3 DELETE RECORDS:

This program assists the user in deleting records from the nine basic files concurrently. In addition, it displays the following selections:

1. YOU ARE ABOUT TO PERMANENTLY DELETE SELECTED RECORDS FROM FILES
0. EXIT (to the MODIFY RECORDS MENU)

1.6 CREATE REPORTS:

Allows the user to create ad hoc reports. The selections are:

1. CREATE NEW REPORT
2. LIST EXISTING REPORT FILES
0. EXIT (to the TIGER MAIN MENU)

1.6.1 CREATE NEW REPORT:

Defaults the user to the dBASE III+ ASSIST menu.

1.6.2 LIST EXISTING REPORT FILES:

Allows the user to view all report files.

1.7 CREATE QUERIES:

Allows the user to create ad hoc query relationships. The selections are:

1. CREATE NEW QUERY
2. LIST QUERY FILES
0. EXIT (to the TIGER MAIN MENU)

1.7.1 CREATE NEW QUERY:

Defaults the user to the dBASE III+ ASSIST menu.

1.7.2 LIST QUERY FILES:

Allows the user view all query files.

1.8 PRINT REPORTS:

Allows the user to print reports that come from the data files. The selections are:

1. PRINT BASIC REPORTS
2. PRINT ANY REPORT
0. EXIT (to the TIGER MAIN MENU)

1.8.1 PRINT BASIC REPORTS:

Allows the user to print the basic reports by inputing a file name.

1.8.2 PRINT ANY REPORT:

Allows the user to print a report based on the primary data files. The selections are:

1. AIRCRAFT
2. CHARACTERISTICS
3. PERFORMANCE
4. RATIOS/FACTORS
5. WEIGHT
6. FATIGUE TEST
7. FLIGHT TEST
8. STATIC TEST.RPT
9. WIND TUNNEL TEST.RPT
0. EXIT (to the PRINT REPORTS MENU)

2.0 INTRODUCTION:

The TIGER data base system is used to provide a relational method to input, access and compare data on the Test and Evaluation cost drivers of military aircraft. This program will allow the user to work with existing files, add data, edit data and delete records from the following nine applicable files:

1. AIRCRAFT
2. CHARACTERISTICS
3. PERFORMANCE
4. RATIOS/FACTORS
5. WEIGHT
6. FATIGUE TEST
7. FLIGHT TEST
8. STATIC TEST
9. WIND TUNNEL TEST

2.1 Procedures:

This program is designed to be operated using dBASE III+ with an IBM-PC and hard disk drive to contain the required files. Ensure the required files are resident on the hard disk drive prior to operation.

1. Commands to perform.
   a. Type: DBASE (enables the db.exe file).
   b. Type: DO TIGER or F9 function key
   (activates main menu).

2.2 TIGER MAIN MENU:

This menu is displayed to provide the user access to the data base and the following options to view and manipulate data:

1. LIST STRUCTURES
2. BROWSE FILES
3. JOIN FILES
4. MODIFY RECORDS
5. CREATE REPORTS
6. CREATE QUERIES
7. PRINT REPORT
0. EXIT (to dBASE III+ ASSIST menu)

2.2.1 SELECTING SUB-MENUS:

Select an option from the TIGER MAIN MENU by typing the number of the corresponding option desired.

1. Commands to perform:
   a. Type: 1, 2, 3, 4, 5, 6, 7, or 0 <cr>

3.0 LIST STRUCTURES:

The LIST STRUCTURES menu is displayed when called as an option from the TIGER MAIN MENU. This menu provides the user the opportunity to view and print the structure of a data file with the following selections:

1. LIST BASIC STRUCTURES
2. LIST ANY STRUCTURE
0. EXIT (to the TIGER MAIN MENU)

SELECTING LIST STRUCTURES OPTIONS:

Select an option from the LIST STRUCTURES menu by typing the number of the corresponding option desired.

1. Commands to perform:
   a. Type: 1, 2 or 0 <cr>

3.1 LIST BASIC STRUCTURES:

The LIST BASIC STRUCTURES menu is displayed when called as an option from the LIST STRUCTURES menu. This menu provides the user the opportunity to view and print the structure of the nine basic data files with the following selections:

1. AIRCRAFT
2. CHARACTERISTICS
3. PERFORMANCE
4. RATIOS/FACTORS
5. WEIGHT
6. FATIGUE TEST
7. FLIGHT TEST
8. STATIC TEST
9. WIND TUNNEL TEST
0. EXIT (exit to the LIST STRUCTURES MENU)

SELECTING DATA FILE OPTIONS:

Select an option from the LIST BASIC STRUCTURES menu by typing the number of the corresponding option desired.

1. Commands to perform:
   a. Type: 1, 2, 3, 4, 5, 6, 7, 8, 9 or 0 <cr>

3.1.1 SELECTED DATA FILES:

These data files are called from the LIST BASIC STRUCTURES menu and allows the user to view and print the structure of the selected data file.

When this option is selected the monitor will query the user:

"Direct this output to the printer? (Y/N)"

If printed copy is desired:

1. Command to perform:
   a. Type: Y<cr>

If printed copy is not desired:

1. Command to perform:
   a. Type: N<cr>

After selecting Y/N the list will scroll on the screen and display the requested structure.

RETURN FROM SELECTED DATA FILE OPTION:

To return from viewing a selected data file structure, the user may type <esc> which will return the screen to the previous menu.

1. Commands to perform:
   a. Type: <esc>

3.1.2 LIST ANY STRUCTURE:

The LIST ANY STRUCTURE option is called from the LIST STRUCTURES menu and allows the user to view and print the structure of any data file by typing a specific database filename.

1. Commands to perform:
   a. Type: <filename><cr>

When this option is selected the monitor will query the user:

"Direct this output to the printer? (Y/N)"

If printed copy is desired:

1. Command to perform:
   a. Type: Y<cr>

If printed copy is not desired:

1. Command to perform:
   a. Type: N<cr>

After selecting Y/N the listing will scroll on the screen and display the requested structure.

RETURN FROM LIST ANY STRUCTURE OPTION:

To return from viewing a data file, the user may type <esc> which will return the screen to the previous menu.

1. Commands to perform:
   a. Type: <esc>

3.2 BROWSE FILES:

The BROWSE FILES menu is displayed when called as an option from the TIGER MAIN MENU. This menu provides the user the opportunity to view but not manipulate applicable files with the following selections:

1. BROWSE BASIC FILES
2. BROWSE ANY FILE
0. EXIT (to the TIGER MAIN MENU)

SELECTING SUB-MENUS:

Select an option from the BROWSE FILES menu by typing the number of the corresponding option desired.

1. Commands to perform:
   a. Type: 1, 2 or 0 <cr>

3.2.1 BROWSE BASIC FILES:

The BROWSE BASIC FILES menu is displayed when called as an option from the BROWSE FILES menu. This menu provides the user the opportunity to view but not manipulate the nine basic data files with the following selections:

1. AIRCRAFT
2. CHARACTERISTICS
3. PERFORMANCE
4. RATIOS/FACTORS
5. WEIGHT
6. FATIGUE TEST
7. FLIGHT TEST
8. STATIC TEST
9. WIND TUNNEL TEST
0. EXIT (to the BROWSE FILES MENU)

SELECTING DATA FILE OPTIONS:

Select an option from the BROWSE BASIC FILES menu by typing the number of the corresponding option desired.

1. Commands to perform:
   a. Type: 1, 2, 3, 4, 5, 6, 7, 8, 9 or 0 <cr>

3.2.1.1 SELECTED DATA FILES:

These data files are called from the BROWSE BASIC FILE menu and allows the user to view but not manipulate the data contained in the selected file.

RETURN FROM SELECTED DATA FILE OPTION:

To return from browsing a selected data file, the user may type <esc> which will return the screen to the previous menu.

1. Commands to perform:
   a. Type: <esc>

3.2.2 BROWSE ANY FILE:

The BROWSE ANY FILE menu is displayed when called as an option from the BROWSE FILES menu. This menu provides the user the opportunity to view but not manipulate any files with the following selections:

1. BROWSE ANY FILE
2. LIST FILES
0. EXIT (to the BROWSE FILES MENU)

SELECTING SUB-MENU OPTIONS:

Select an option from the BROWSE ANY FILE menu by typing the number of the corresponding option desired.

1. Commands to perform:
   a. Type: 1, 2 or 0 <cr>

3.2.2.1 BROWSE ANY FILE:

The BROWSE ANY FILE option is called from the BROWSE ANY FILE menu and allows the user to view a specific database file by typing a specific database filename.

1. Commands to perform:
   a. Type: <filename><cr>

When this option is selected the monitor will query the user:

"Direct this output to the printer? (Y/N)"

If printed copy is desired:

1. Command to perform:
    a. Type: Y<cr>

If printed copy is not desired:

1. Command to perform:
    a. Type: N<cr>

After selecting Y/N the requested file will scroll on the screen.

RETURN FROM BROWSE ANY FILE OPTION:

To return from viewing a database file, the user may type <esc> which will return the screen to the previous menu.

1. Commands to perform:
    a. Type: <esc>

3.2.2.2 LIST FILES:

The LIST FILES option is called from the BROWSE ANY FILE menu and allows the user to view a directory listing of current database files.

RETURN FROM DATABASE FILE LISTING OPTION:

To return from viewing a database file listing, the user may type <esc> which will return the screen to the previous menu.

1. Commands to perform:
    a. Type: <esc>

3.3 JOIN FILES:

The JOIN FILE menu is displayed when called as an option from the TIGER MAIN MENU. This menu provides the user the opportunity to list existing files and join files with the following selections:

1. LIST EXISTING FILES
2. JOIN FILES
3. JOIN TO FORM SPECS
0. EXIT (to the TIGER MAIN MENU)

3.3.1 LIST EXISTING FILES:

The LIST EXISTING FILES option is called from the JOIN FILE menu and allows the user to view and print a directory listing of existing database files.

When this option is selected the monitor will query the user:

"Direct this output to the printer? (Y/N)"

If printed copy is desired:

1. Command to perform:
    a. Type: Y<cr>

If printed copy is not desired:

1. Command to perform:
    a. Type: N<cr>

After selecting Y/N the requested listing will scroll on the screen.

RETURN FROM EXISTING FILES LISTING OPTION:

To return from viewing an existing files listing, the user may type <esc> which will return the screen to the previous menu.

1. Commands to perform:
    a. Type: <esc>

3.3.2 JOIN FILES:

The JOIN FILES option is called from the JOIN FILE menu and allows the user to join two selected data files on the MODEL field with a <FILENAME> specified for the new join file.

When this option is selected the monitor will query the user:

"Enter filename 1..."

1. Commands to perform:
   a. Type: <FILENAME> <cr>

"Enter filename 2..."

1. Commands to perform:
   a. Type: <FILENAME> <cr>

"Enter new filename..."

1. Commands to perform:
   a. Type: <FILENAME> <cr>

RETURN FROM JOIN FILES OPTION:

Following entry of the desired filenames, the program will join the desired files and return to the JOIN FILE menu.

3.3.3 JOIN TO FORM SPECS:

The JOIN TO FORM SPECS option is called from the JOIN FILES MENU and allows the user to view and print a specifications structure of the existing database files.

When this option is selected the monitor will query the user:

"Direct this output to the printer? (Y/N)"

If printed copy is desired:

1. Command to perform:
   a. Type: Y<cr>

If printed copy is not desired:

1. Command to perform:
   a. Type: N<cr>

After selecting Y/N the requested specifications chart will scroll on the screen.

RETURN FROM JOIN TO FORM SPECS OPTION:

To return from viewing a specifications chart, the user may type <esc> which will return the screen to the previous menu.

1. Commands to perform:
   a. Type: <esc>

3.4 MODIFY RECORDS:

When the user selects this option four selections are available:

1. ADD AIRCRAFT MODEL
2. EDIT RECORDS
3. DELETE RECORDS
0. EXIT (to the TIGER MAIN MENU)

3.4.1 ADD AIRCRAFT MODEL:

This program assists the user in adding a new model aircraft to all of the nine basic files concurrently. This also does an automatic sort to place the new aircraft in alpha-numeric order.

When this option is selected the monitor will query the user to input the new model:

1. Command to perform:
   a. Type: Model<cr>

RETURN FROM ADD AIRCRAFT MODEL OPTION:

To return from adding a new aircraft, the user may type <CTRL - End> which will return the screen to the previous menu.

3.4.2 EDIT RECORDS:

This program assists the user in editing records in the nine basic files. **The user must be cautioned: in this selection you will be editting only the file you have selected, you will not edit all the sructures simultaneously. In addition, if you edit the model, it will only be edited in the structure selected. In order to ensure continuity among all structures you will have to individually modify the model attribute in the remaining structures.** The selections are:

1. AIRCRAFT
2. CHARACTERISTICS
3. PERFORMANCE
4. RATIOS/FACTORS
5. WEIGHT
6. FATIGUE TEST
7. FLIGHT TEST
8. STATIC TEST
9. WIND TUNNEL TEST
0. EXIT (to the MODIFY RECORDS MENU)

Select an option from the BROWSE BASIC FILES menu by typing the number of the corresponding option desired.

1. Commands to perform:
   a. Type: 1, 2, 3, 4, 5, 6, 7, 8, 9 or 0 <cr>

RETURN FROM EDIT RECORDS OPTION:

To return from editing a record, the user may type <esc> which will save the changes and return the screen to the previous menu.

3.4.3 DELETE RECORDS:

This program assists the user in deleting records from the nine basic files concurrently. It does an automatic pack to ensure the remaining models are maintained in alpha-numeric order. In addition, it displays the following selections:

1. YOU ARE ABOUT TO PERMANENTLY DELETE SELECTED RECORDS FROM FILES
0. EXIT (to the MODIFY RECORDS MENU)

RETURN FROM DELETE RECORDS OPTION:

To return from deleting a record, the user may type <esc> which will return the screen to the previous menu.

3.5 CREATE REPORT:

The CREATE REPORT menu is displayed when called as an option from the TIGER MAIN MENU. This menu provides the user the opportunity to create an ad hoc report or view a listing of existing report files with the following selections:

1. CREATE NEW REPORT
2. LIST EXISTING REPORT FILES

0. EXIT (to the TIGER MAIN MENU)

SELECTING CREATE REPORT OPTIONS:

Select an option from the CREATE REPORT menu by typing the number of the corresponding option desired.

1. Commands to perform:
   a. Type: 1, 2 or 0 <cr>

3.5.1 CREATE NEW REPORT:

The CREATE NEW REPORT option is called from the CREATE REPORT menu and allows the user to create an ad hoc report utilizing the dBASE III+ ASSIST function.

1. Commands to perform:
   a. Type: 1

*** **a. User is directed to the dBASE III+ ASSIST function.**

RETURN FROM CREATE NEW REPORT OPTION:

To return from creating an ad hoc report, the user may type <esc> which will return the screen to the previous menu.

1. Commands to perform:
   a. Type: <esc>

3.5.2 LIST EXISTING REPORT FILES:

The LIST EXISTING REPORT FILES option is called from the CREATE REPORT menu and allows the user to view a directory listing of existing report files.

RETURN FROM EXISTING REPORT FILES LISTING OPTION:

To return from viewing an existing report files listing, the user may type <esc> which will return the screen to the previous menu.

1. Commands to perform:
   a. Type: <esc>

3.6 CREATE QUERIES:

The CREATE QUERIES menu is displayed when called as an option from the TIGER MAIN MENU. This menu provides the user the opportunity to create ad hoc query relationships with the following selectaons:

1. CREATE NEW QUERY
2. LIST QUERY FILES
0. EXIT (to the TIGER MAIN MENU)

SELECTING CREATE QUERIES OPTIONS:

Select an option from the CREATE QUERIES menu by typing the number of the corresponding option desired.

1. Commands to perform:
   a. Type: 1, 2 or 0 <cr>

3.6.1 CREATE NEW QUERY:

The CREATE NEW QUERY option is displayed when called as an option from the CREATE QUERY menu. This option allows the user to create an ad hoc query using the dBASE III+ ASSIST function.

1. Commands to perform:
   a. Type: 1

*** **a. User is directed to the dBASE III+ ASSIST function.**

3.6.2 LIST QUERY FILES:

The LIST QUERY FILES option is called from the CREATE QUERY menu and allows the user to view all query files.

RETURN FROM LIST QUERY FILES OPTION:

To return from viewing a query file listing, the user may type <esc> which will return the screen to the previous menu.

1. Commands to perform:
   a. Type: <esc>

3.7 PRINT REPORTS:

The PRINT REPORTS menu is displayed when called as an option from the TIGER MAIN MENU. This menu provides the user the opportunity to send to the printer the following selections:

1. PRINT BASIC REPORTS
2. PRINT ANY REPORT
0. EXIT (to the TIGER MAIN MENU)

SELECTING SUB-MENUS:

Select an option from the PRINT REPORTS menu by typing the number of the corresponding option desired.

1. Commands to perform:
   a. Type: 1, 2, 3, or 0 <cr>

3.7.1 PRINT BASIC REPORTS:

The PRINT BASIC REPORTS menu is displayed when called as an option from the TIGER MAIN MENU. This menu provides the user the opportunity to send to the printer nine standard reports with the following selections:

1. AIRCRAFT
2. CHARACTERISTICS
3. PERFORMANCE
4. RATIOS/FACTORS
5. WEIGHT
6. FATIGUE TEST
7. FLIGHT TEST
8. STATIC TEST
9. WIND TUNNEL TEST
0. EXIT (to the PRINT REPORTS MENU)

SELECTING SUB-MENUS:

Select an option from the PRINT BASIC REPORTS menu by typing the number of the corresponding option desired.

1. Commands to perform:
   a. Type: 1, 2, 3, 4, 5, 6, 7, 8, 9, or 0 <cr>

RETURN FROM PRINT BASIC REPORTS OPTION:

To return from printing a basic report, the user may type <esc> which will return the screen to the previous menu.

1. Commands to perform:
   a. Type: <esc>

3.7.2 PRINT ANY REPORT:

Allows the user to print a report based on the primary data files. The selections are:

1. PRINT ANY REPORT
2. LIST REPORTS
0. EXIT (to the PRINT REPORTS MENU)

3.7.2.1 PRINT ANY REPORT:

Allows the user to print a report based on the following selections:

1. AIRCRAFT
2. CHARACTERISTICS
3. PERFORMANCE
4. RATIOS/FACTORS
5. WEIGHT
6. FATIGUE TEST
7. FLIGHT TEST
8. STATIC TEST
9. WIND TUNNEL TEST
0. EXIT (to the PRINT REPORTS MENU)

SELECTING SUB-MENUS:

Select an option from the PRINT ANY REPORTS menu by typing the number of the corresponding option desired.

1. Commands to perform:
   a. Type: 1, 2, 3, 4, 5, 6, 7, 8, 9, or 0 <cr>

RETURN FROM PRINT ANY REPORTS OPTION:

To return from printing a report, the user may type <esc> which will return the screen to the previous menu.

1. Commands to perform:
   a. Type: <esc>

3.7.2.2 LIST REPORTS:

Allows the user to view and print the reports that are available.

RETURN FROM LIST REPORTS OPTION:

To return from viewing or printing the available reports, the user may type <esc> which will return the screen to the previous menu.

1. Commands to perform:
   a. Type: <esc>

APPENDIX E: REPORTS

***** DUE TO THE PROPRIETARY NATURE OF THE DATA THIS THESIS WILL USE "XX" TO INDICATE WHERE SUCH DATA WAS AVAILABLE AND USED IN THE DATABASE *****

AIRCRAFT

MODEL	MISSION	MFG
A-10A	XX	XX
A-18	XX	XX
A 4A	XX	XX
A-5A	XX	XX
A-6A	XX	XX
A-7	XX	XX
AV-8B	XX	XX
B-1	XX	XX
B 45C	XX	XX
B-52F	XX	XX
B-52G	XX	XX
B-58A	XX	XX
C-130B	XX	XX
C-130E	XX	XX
C 135A	XX	XX
C-141A	XX	XX
C-5A	XX	XX
E-3A	XX	XX
F-100	XX	XX
F-105	XX	XX
F-111A	XX	XX
F-14A	XX	XX
F-15A	XX	XX
F-16A	XX	XX
F-18	XX	XX
F-4A	XX	XX
F-5	XX	XX
F-84B	XX	XX
F-86D	XX	XX
OV-10	XX	XX
S-3A	XX	XX
T-2	XX	XX
T-38A	XX	XX
T-39	XX	XX
XB-70	XX	XX
YC-130	XX	XX
YC-14	XX	XX
YF 16	XX	XX

FLIGHT TEST DATA

MODEL	FLTHRS	TEVTS	ENGHR	MFGHR	TOOLHR	QCHR	ILSHR	TOTHRS
A-10A			XX	XX	XX	XX		
A-18			XX	XX	XX	XX		
A-4A			XX	XX	XX			XX
A-5A			XX	XX		XX		XX
A-6A			XX	XX	XX	XX		XX
A-7	XX		XX					
AV-8B			XX					
B-1			XX					XX
B-45C								
B-52F			XX					XX
B-52G								
B-58A			XX	XX	XX	XX		XX
C-130B								
C-130E								
C-135A			XX					XX
C-141A	XX		XX					XX
C-5A	XX		XX			XX		XX
E-3A	XX		XX					
F-100								XX
F-105			XX	XX	XX			XX
F-111A	XX		XX	XX	XX	XX		XX
F-14A			XX	XX	XX	XX		XX
F-15A			XX	XX		XX		XX
F-16A	XX		XX	XX	XX	XX		XX
F-18			XX	XX	XX	XX		XX
F-4A			XX	XX		XX		XX
F-5								XX
F-84B								
F-86D								
OV-10			XX	XX				
S-3A	XX		XX	XX	XX	XX		XX
T-2			XX	XX				
T-38A			XX	XX	XX	XX		XX
T-39								XX
XB-70								
YC 130								
YC-14	XX		XX					XX
YF-16	XX		XX	XX	XX	XX		XX

FATIGUE TEST DATA

MODEL	TMOS	THRS	ENGHRS	MFGHRS	TOOLHR	QCHRS	ILSHRS	TOTHRS
A-10A			XX					
A-18			XX					
A-4A								
A-5A			XX	XX				
A-6A								
A-7								
AV-8B								
B-1								
B-45C								
B-52F			XX					
B-52G								
B-58A			XX	XX	XX	XX		XX
C-130B								
C-130E								
C-135A								
C-141A			XX					
C-5A			XX	XX	XX	XX		
E-3A								
F-100								
F-105								
F-111A			XX	XX	XX	XX		XX
F-14A			XX	XX	XX	XX		
F-15A								
F-16A			XX	XX	XX	XX		XX
F-18			XX					
F-4A								
F-5								
F-84B								
F-86D								
OV-10			XX	XX				
S-3A			XX	XX	XX			
T-2			XX	XX				
T-38A								
T-39								
XB-70								
YC-130								
YC-14								
YF-16								

STATIC TEST DATA

MODEL	TMOS	ENGHRS	MFGHRS	TOOLHR	QCHRS	ILSHRS	TOTHRS
A-10A		XX					
A-18		XX					
A-4A							
A-5A		XX	XX				
A-6A							
A-7							
AV-8B							
B-1							
B-45C							
B-52F		XX					
B-52G							
B-58A		XX	XX	XX	XX		XX
C-130B							
C-130E							
C-135A							XX
C-141A		XX					
C-5A		XX	XX	XX			
E-3A							
F-100							
F-105							
F-111A		XX	XX	XX	XX		XX
F-14A		XX	XX	XX	XX		
F-15A							
F-16A		XX	XX	XX	XX		
F-18		XX					
F-4A		XX					
F-5							
F-84B							
F-86D							
OV-10		XX	XX				
S-3A		XX	XX	XX			
T-2		XX	XX				
T-38A							
T-39							
XB-70							
YC-130							
YC-14							
YF-16							

WIND TUNNEL TEST DATA

MODEL	TMOS	THRS	ENGHRS	MFGHRS	TOOLHR	QCHRS	ILSHRS	TOTHRS
A-10A			XX					
A-18			XX					
A-4A			XX					
A-5A			XX	XX				
A-6A			XX					
A-7								
AV-8B								
B-1								
B-45C								
B-52F			XX					
B-52G								
B-58A			XX		XX	XX		XX
C-130B								
C-130E								
C-135A								XX
C-141A			XX					
C-5A			XX					
E-3A								
F-100								
F-105								
F-111A			XX	XX	XX	XX		XX
F-14A			XX	XX	XX	XX		
F-15A								
F-16A			XX		XX	XX		XX
F-18			XX	XX				
F-4A			XX					
F-5								
F-84B								
F-86D								
OV-10			XX	XX				
S-3A			XX	XX				
T-2								
T-38A			XX					
T-39								
XB-70								
YC-130								
YC-14			XX					
YF-16			XX		XX	XX		XX

AIRCRAFT CHARACTERISTICS

MODEL	CREW	1STFL	AWA	VOL	WL	CQ	AVBX	ENG	SSTA	THRUST
A-10A	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
A-18	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
A-4A	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
A-5A	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
A-6A	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
A-7	XX	XX			XX	XX		XX	XX	XX
AV-8B	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
B-1	XX	XX			XX	XX		XX	XX	XX
B-45C	XX									
B-52F	XX	XX			XX	XX		XX	XX	XX
B-52G	XX	XX			XX	XX		XX	XX	XX
B-58A	XX	XX			XX	XX		XX	XX	XX
C-130B	XX	XX			XX	XX		XX	XX	XX
C-130E	XX	XX			XX	XX		XX	XX	XX
C-135A	XX	XX			XX	XX		XX	XX	XX
C-141A	XX	XX			XX	XX		XX	XX	XX
C-5A	XX	XX			XX	XX		XX	XX	XX
E-3A	XX	XX			XX	XX		XX	XX	XX
F-100	XX	XX			XX	XX		XX	XX	XX
F-105	XX	XX			XX	XX		XX	XX	XX
F-111A	XX	XX			XX	XX		XX	XX	XX
F-14A	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
F-15A	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
F-16A	XX	XX			XX	XX	XX	XX	XX	XX
F-18	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
F-4A	XX	XX	XX		XX	XX	XX	XX	XX	XX
F-5	XX	XX			XX	XX		XX	XX	XX
F-84B	XX	XX			XX	XX		XX	XX	XX
F-86D	XX	XX			XX	XX		XX	XX	XX
OV-10	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
S-3A	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
T-2	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
T-38A	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
T-39	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
XB-70	XX									
YC-130	XX	XX			XX	XX		XX		
YC-14	XX	XX			XX	XX		XX		
YF-16	XX	XX			XX	XX		XX	XX	

AIRCRAFT RATIOS/FACTORS

MODEL	LLF	ULF	WE/WS	WE/VOL	GTOW/WS
A-10A	XX	XX	XX	XX	XX
A-18	XX	XX	XX	XX	XX
A-4A	XX	XX	XX	XX	XX
A-5A	XX	XX	XX	XX	XX
A-6A	XX	XX	XX	XX	XX
A-7	XX	XX	XX	XX	XX
AV-8B	XX	XX	XX	XX	XX
B-1			XX		XX
B-45C			XX		XX
B-52F			XX		XX
B-52G			XX		XX
B-58A			XX		XX
C-130B			XX		XX
C-130E		XX	XX		XX
C-135A			XX		XX
C-141A			XX		XX
C-5A			XX		XX
E-3A			XX		XX
F-100			XX		XX
F-105					
F-111A			XX		XX
F-14A	XX	XX	XX	XX	XX
F-15A	XX	XX	XX	XX	XX
F-16A	XX	XX	XX	XX	XX
F-18	XX	XX	XX	XX	XX
F-4A	XX	XX	XX		XX
F-5					
F-84B		XX	XX		XX
F-86D			XX		XX
OV-10	XX	XX	XX	XX	XX
S-3A	XX	XX	XX	XX	XX
T-2	XX	XX	XX	XX	XX
T-38A	XX	XX	XX	XX	XX
T-39	XX	XX	XX	XX	XX
XB-70			XX		XX
YC-130					XX
YC-14					
YF-16		XX	XX		XX

AIRCRAFT WEIGHT

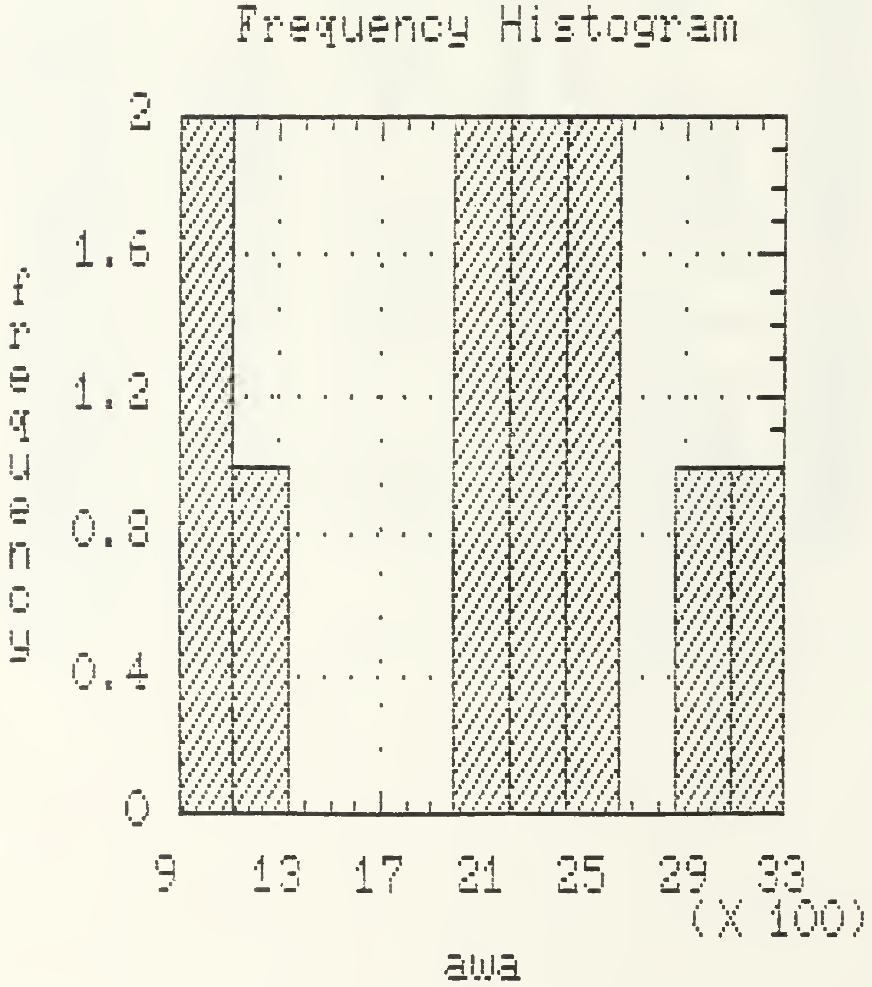
MODEL	WS	WA	WE	GTOW	WAVU	WAVI	MAXWSS
A-10A	XX	XX	XX	XX	XX	XX	XX
A-18	XX	XX	XX	XX	XX	XX	XX
A-4A	XX	XX	XX	XX	XX	XX	XX
A-5A	XX	XX	XX	XX	XX	XX	
A-6A	XX	XX	XX	XX	XX	XX	XX
A-7	XX	XX	XX	XX	XX	XX	XX
AV-8B	XX	XX	XX	XX	XX	XX	XX
B-1	XX	XX	XX	XX	XX	XX	
B-45C	XX		XX	XX	XX		XX
B-52F	XX		XX	XX	XX	XX	
B-52G	XX	XX	XX	XX	XX	XX	
B-58A	XX	XX	XX	XX	XX	XX	
C-130B	XX	XX	XX	XX	XX	XX	
C-130E	XX		XX	XX	XX	XX	
C-135A	XX		XX	XX	XX		
C-141A	XX		XX	XX	XX	XX	
C-5A	XX	XX	XX	XX	XX	XX	
E-3A	XX	XX	XX	XX	XX	XX	
F-100	XX		XX	XX	XX	XX	
F-105			XX	XX			
F-111A	XX	XX	XX	XX	XX	XX	
F-14A	XX	XX	XX	XX	XX	XX	
F-15A	XX	XX	XX	XX	XX	XX	
F-16A	XX	XX	XX	XX	XX	XX	
F-18	XX	XX	XX	XX	XX	XX	XX
F-4A	XX	XX	XX	XX	XX	XX	XX
F-5			XX	XX			
F-84B	XX		XX	XX	XX		
F-86D	XX	XX	XX	XX	XX	XX	
OV-10	XX	XX	XX	XX	XX	XX	XX
S-3A	XX	XX	XX	XX	XX	XX	XX
T-2	XX	XX	XX	XX	XX	XX	
T-38A	XX	XX	XX	XX	XX	XX	XX
T-39	XX	XX	XX	XX	XX	XX	
XB-70	XX		XX	XX	XX	XX	
YC-130	XX	XX		XX	XX	XX	
YC-14							
YF-16	XX	XX	XX	XX	XX	XX	

AIRCRAFT PERFORMANCE

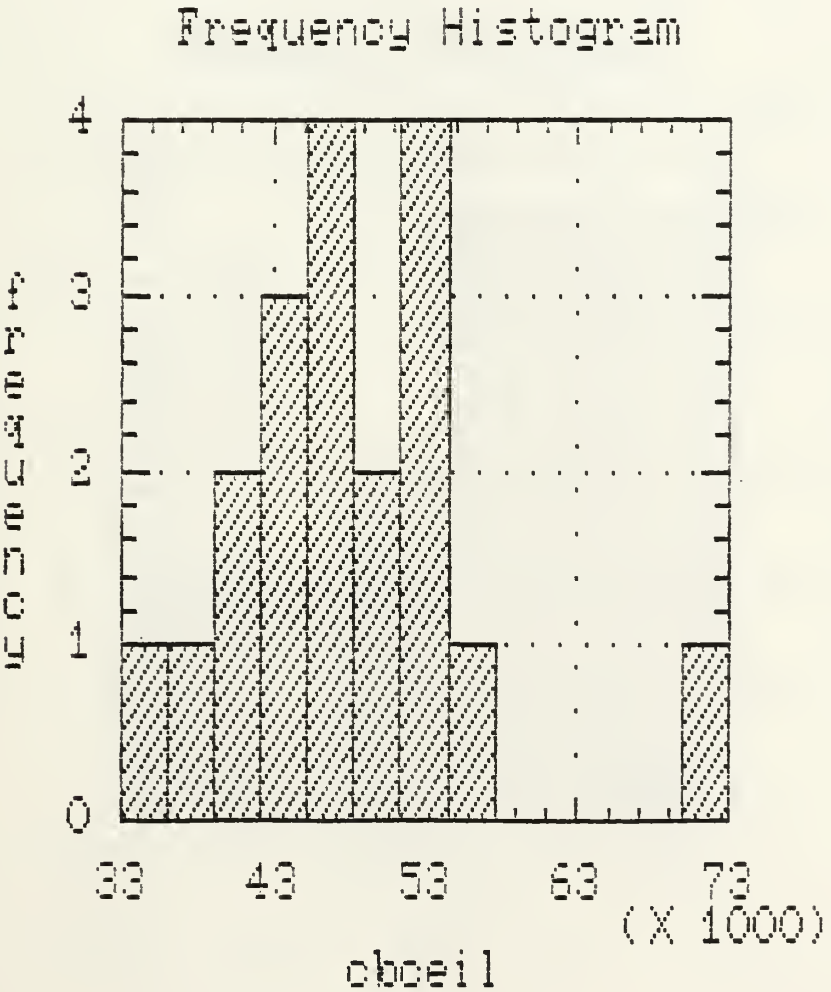
MODEL	VMAXA	VMAXS	VCRUISE	CBTCEIL	SERCEIL	CBTRADIUS
A-10A	XX	XX	XX	XX	XX	XX
A-18	XX	XX	XX	XX		XX
A-4A	XX	XX	XX	XX	XX	XX
A-5A	XX	XX	XX	XX	XX	XX
A-6A	XX	XX	XX	XX	XX	XX
A-7	XX	XX	XX	XX	XX	XX
AV-8B	XX	XX	XX			XX
B-1	XX	XX	XX	XX	XX	XX
B-45C		XX			XX	XX
B-52F	XX			XX	XX	XX
B-52G	XX		XX			
B-58A	XX	XX		XX	XX	XX
C-130B	XX		XX			
C-130E	XX	XX	XX		XX	XX
C-135A	XX		XX	XX	XX	XX
C-141A	XX		XX	XX	XX	XX
C-5A	XX		XX	XX	XX	XX
E-3A	XX		XX			
F-100	XX		XX	XX	XX	XX
F-105	XX		XX	XX	XX	XX
F-111A	XX		XX	XX	XX	XX
F-14A	XX	XX	XX		XX	
F-15A	XX	XX	XX		XX	
F-16A	XX	XX			XX	XX
F-18	XX	XX	XX	XX		XX
F-4A	XX	XX	XX	XX	XX	XX
F-5	XX		XX	XX	XX	XX
F-84B	XX	XX	XX	XX	XX	
F-86D	XX				XX	XX
OV-10	XX	XX	XX		XX	
S-3A	XX	XX	XX		XX	XX
T-2	XX	XX	XX			
T-38A	XX	XX	XX	XX	XX	XX
T-39	XX	XX	XX	XX	XX	XX
XB-70						
YC-130						
YC-14						
YF-16						

APPENDIX F: ONE WAY ANALYSIS OF VARIANCE

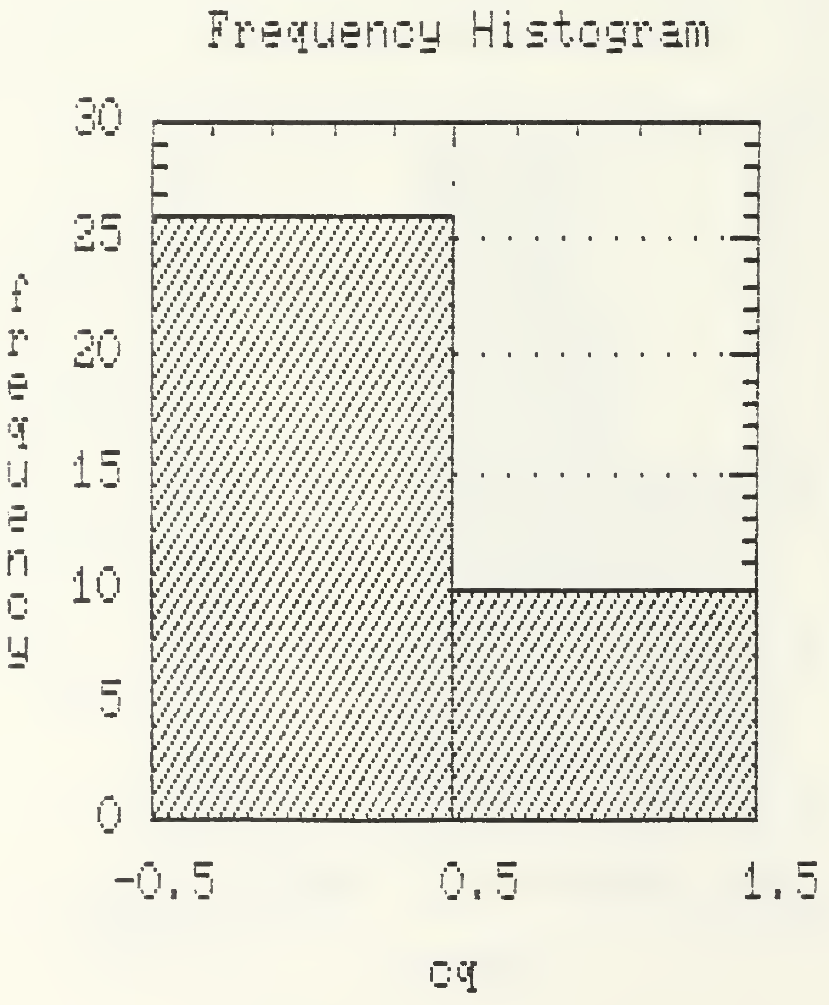
```
                      One-Sample Analysis Results

                                          awa
Sample Statistics: Number of Obs.         11
                   Average                2118.62
                   Variance               561931
                   Std. Deviation         749.62
                   Median                 2217

Confidence Interval for Mean:             95    Percent
                   Sample 1               1615.08 2622.55     10 D.F.

Confidence Interval for Variance:         0      Percent
                   Sample 1


Hypothesis Test for HO: Mean = 0          Computed t statistic = 9.37451
                      vs Alt: NE          Sig. Level = 2.86391E-6
                   at Alpha = 0.05        so reject HO.
```



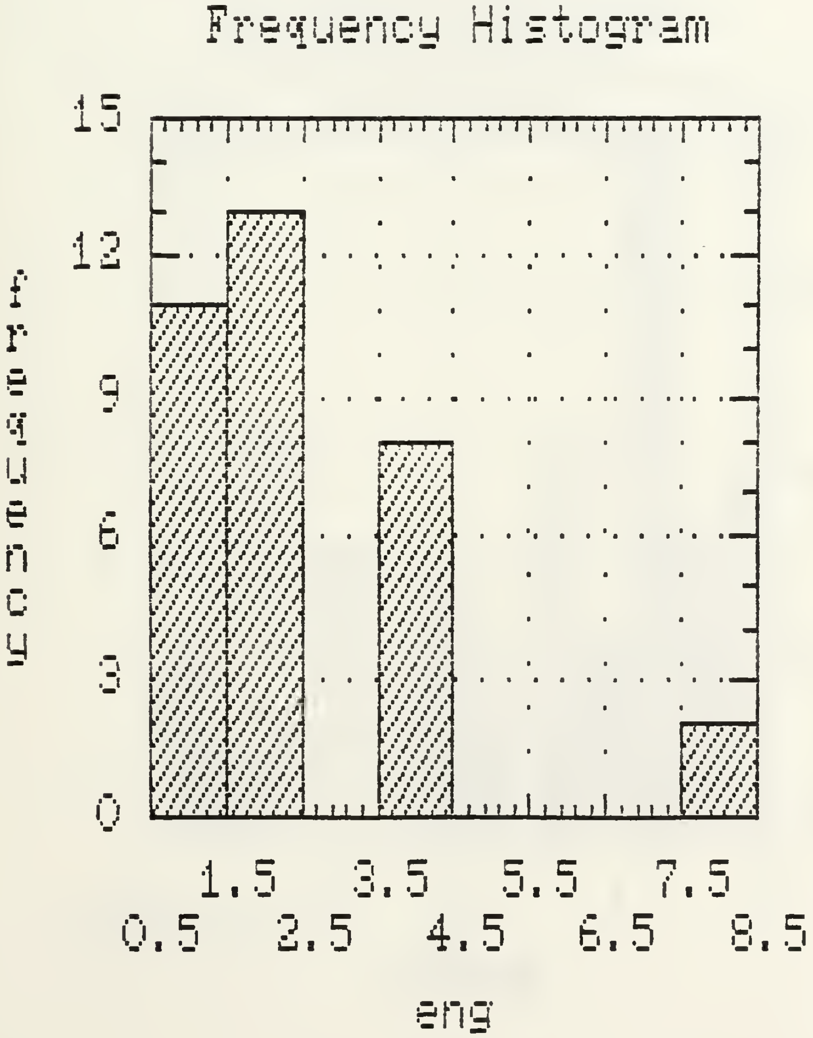
```
                              One-Sample Analysis Results
========================================================================================
                                                cboeil
Sample Statistics: Number of Obs.               19
                   Average                      47805.3
                   Variance                     6.6438E7
                   Std. Deviation               8150.95
                   Median                       46900

Confidence Interval for Mean:                   95     Percent
                   Sample 1                     43875.7 51734.9     18 D.F.

Confidence Interval for Variance:               0       Percent
                   Sample 1


Hypothesis Test for HO: Mean = 0                Computed t statistic = 25.5649
                       vs Alt: NE               Sig. Level = 1.33227E-15
                    at Alpha = 0.05             so reject HO.
```



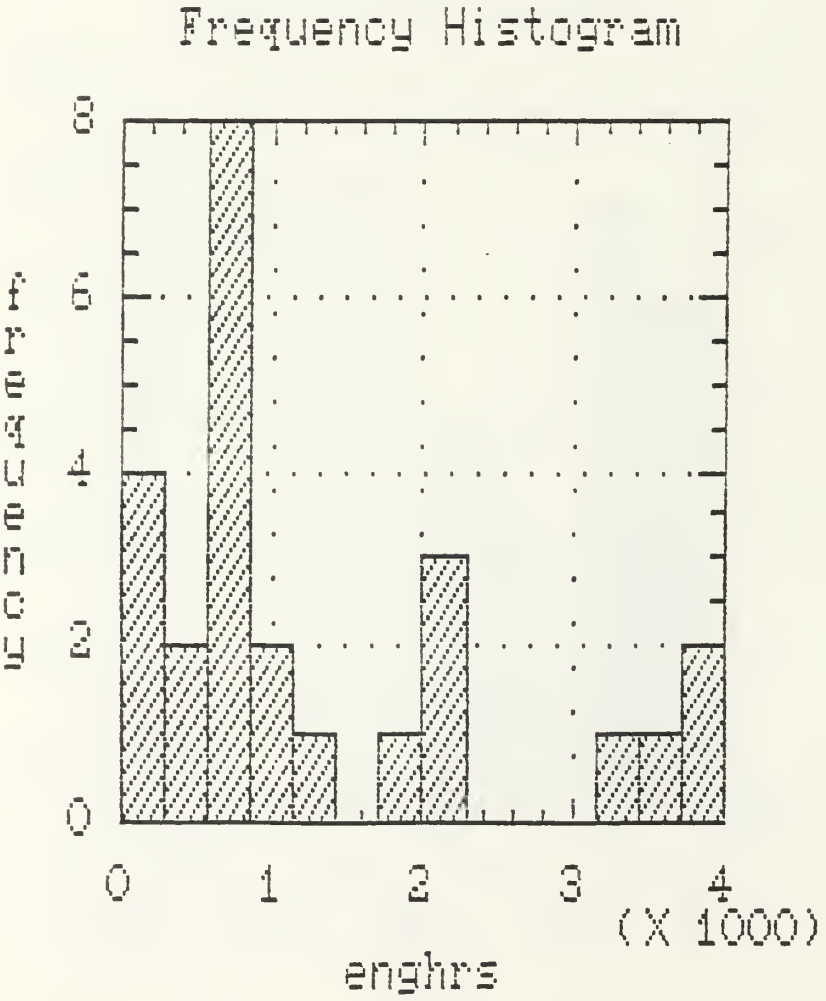
```
                        One-Sample Analysis Results
==========================================================================

                                           cq
Sample Statistics: Number of Obs.          36
                   Average                 0.277778
                   Variance                0.206349
                   Std. Deviation          0.454257
                   Median                  0

Confidence Interval for Mean:              95    Percent
                   Sample 1                0.124044 0.431512     35 D.F.

Confidence Interval for Variance:          0      Percent
                   Sample 1


Hypothesis Test for HO: Mean = 0           Computed t statistic = 3.669
                       vs Alt: NE          Sig. Level = 8.03748E-4
                    at Alpha = 0.05        so reject HO.
```



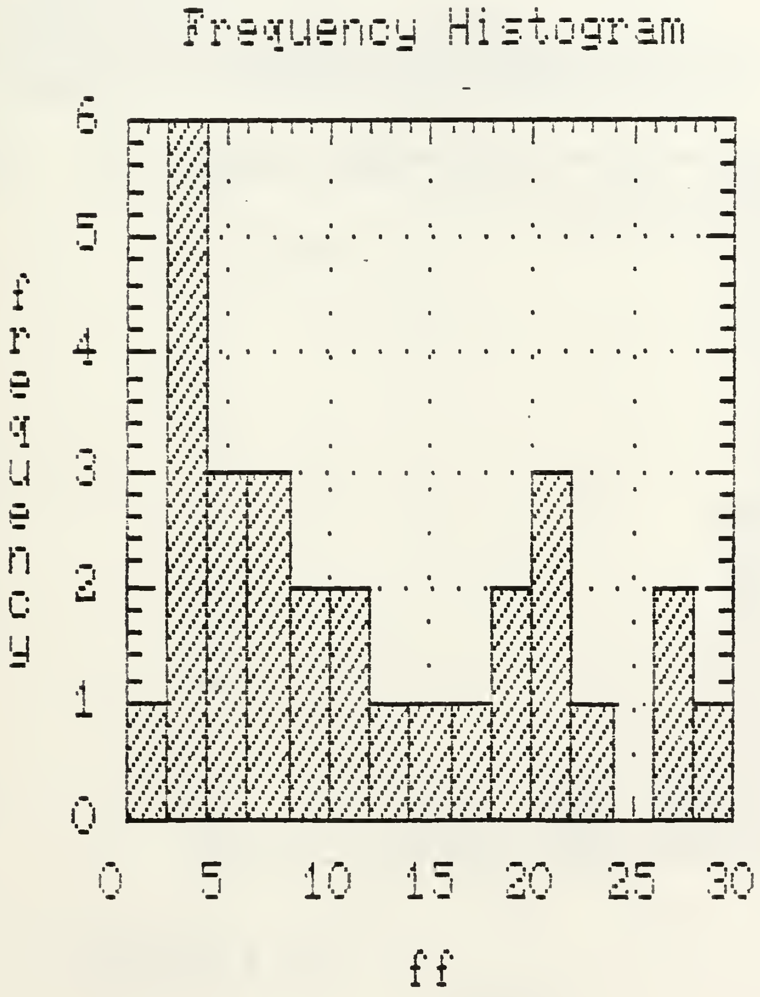
```
                              One-Sample Analysis Results
===========================================================================
                                          eng
Sample Statistics: Number of Obs.         34
                   Average                2.5
                   Variance               3.22727
                   Std. Deviation         1.79646
                   Median                 2

Confidence Interval for Mean:             95    Percent
                   Sample 1               1.87304 3.12696     33 D.F.

Confidence Interval for Variance:         0      Percent
                   Sample 1


Hypothesis Test for H0: Mean = 0          Computed t statistic = 8.1145
                       vs Alt: NE         Sig. Level = 2.2925E-9
                   at Alpha = 0.05        so reject H0.
```



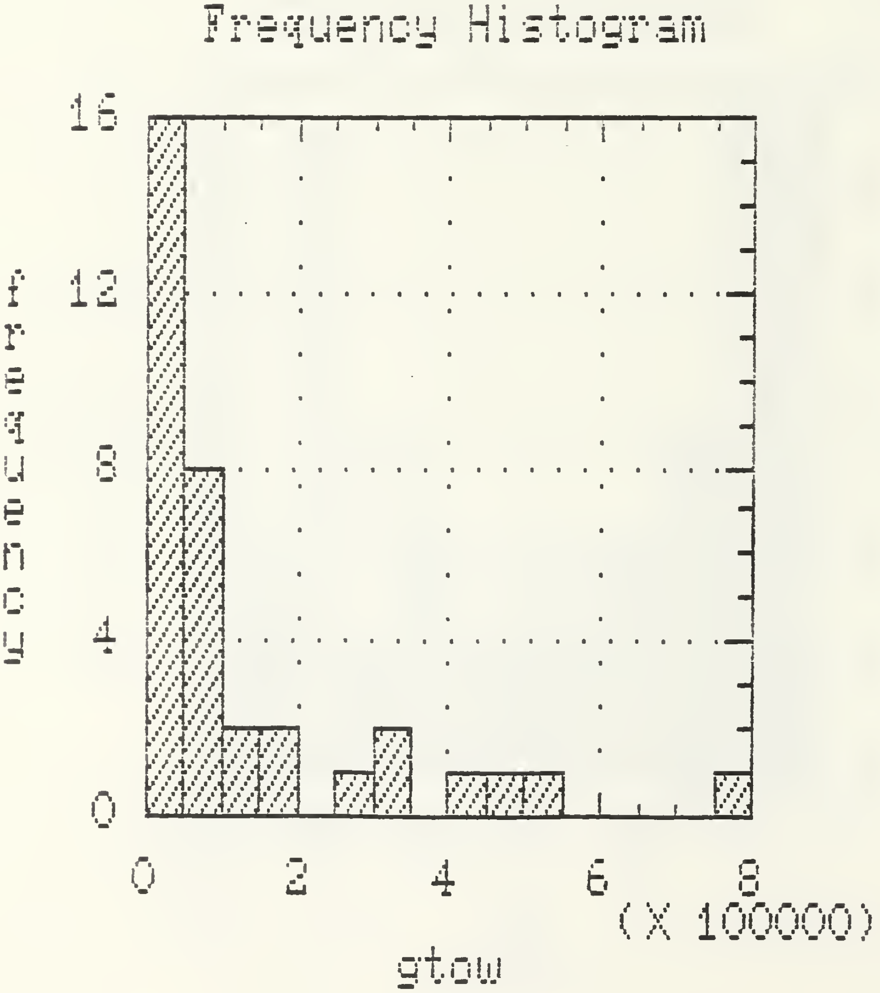
```
                          One-Sample Analysis Results
================================================================================
                                           enghrs
Sample Statistics: Number of Obs.          25
                   Average                 1350.06
                   Variance                1.39592E6
                   Std. Deviation          1181.49
                   Median                  820

Confidence Interval for Mean:              95     Percent
                   Sample 1                862.244 1837.87      24 D.F.

Confidence Interval for Variance:          0      Percent
                   Sample 1


Hypothesis Test for H0: Mean = 0           Computed t statistic = 5.71335
                       vs Alt: NE          Sig. Level = 6.92241E-6
                    at Alpha = 0.05        so reject H0.
```

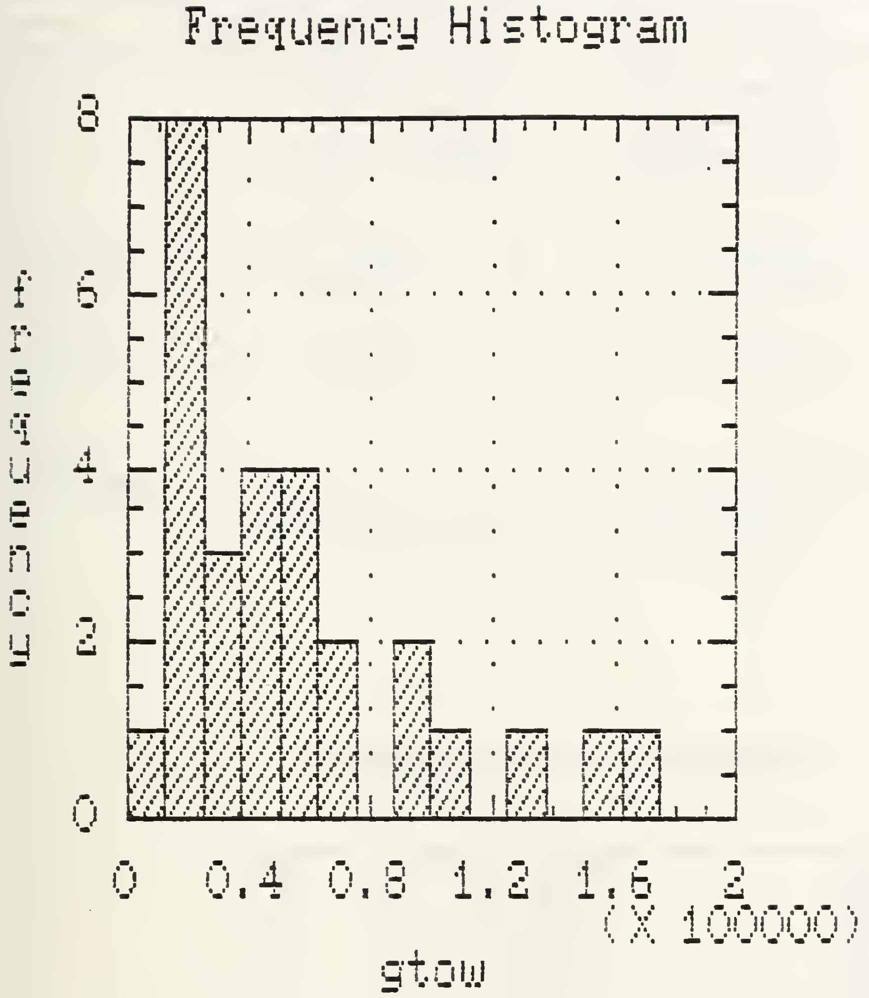


```
                        One-Sample Analysis Results
===============================================================================
                                          ff
Sample Statistics: Number of Obs.         31
                   Average                11.0458
                   Variance               77.5108
                   Std. Deviation         8.80402
                   Median                 8.33

Confidence Interval for Mean:             95     Percent
                   Sample 1               7.81571 14.2759     30 D.F.

Confidence Interval for Variance:         0       Percent
                   Sample 1


Hypothesis Test for HO: Mean = 0          Computed t statistic = 6.9855
                       vs Alt: NE         Sig. Level = 9.22532E-8
                     at Alpha = 0.05      so reject HO.
```

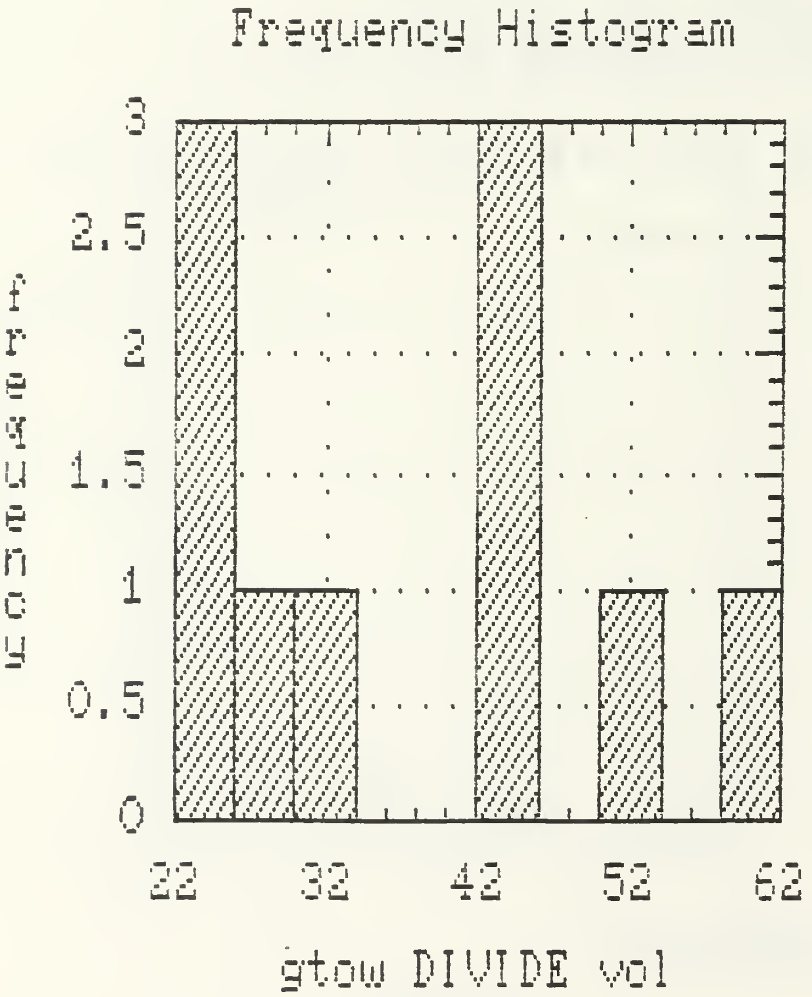


```
                         One-Sample Analysis Results
==========================================================================
                                         gtow
Sample Statistics: Number of Obs.        35
                   Average               134429
                   Variance              3.25712E10
                   Std. Deviation        180475
                   Median                56000

Confidence Interval for Mean:            95    Percent
                   Sample 1              72419 196438     34 D.F.

Confidence Interval for Variance:        0      Percent
                   Sample 1


Hypothesis Test for H0: Mean = 0         Computed t statistic = 4.40666
                            vs Alt: NE   Sig. Level = 9.95387E-5
                     at Alpha = 0.05     so reject H0.
```

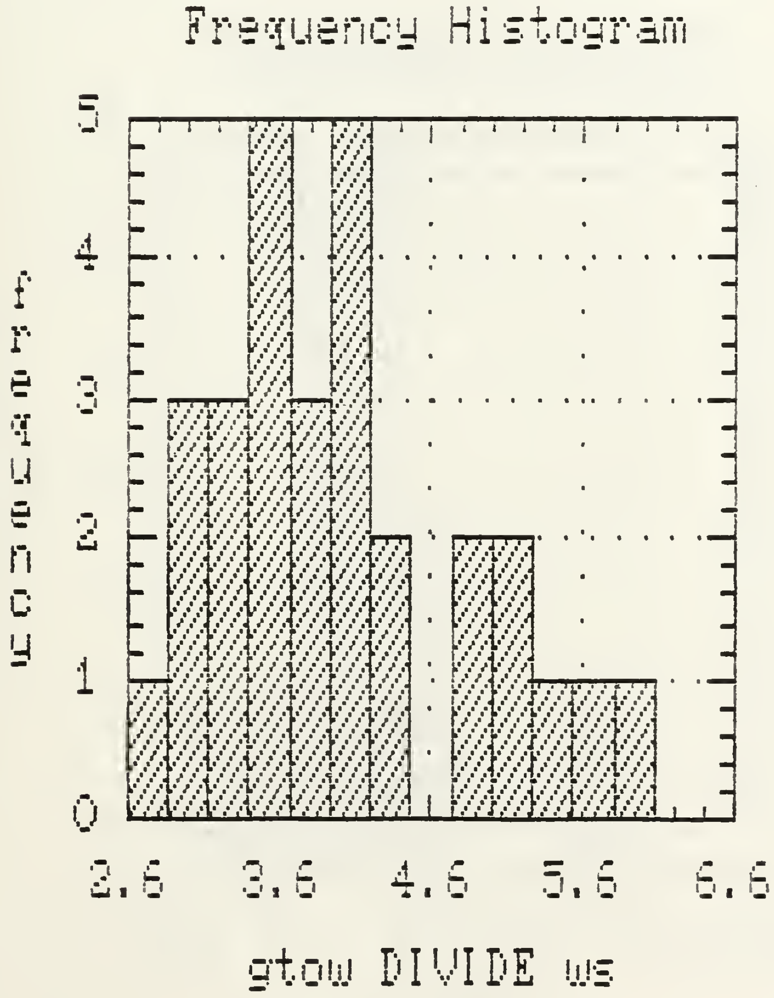



Frequency Histogram
frequency
0
2
4
6
8
0
0.4
0.8
1.2
1.6
2
(X 100000)
gtow

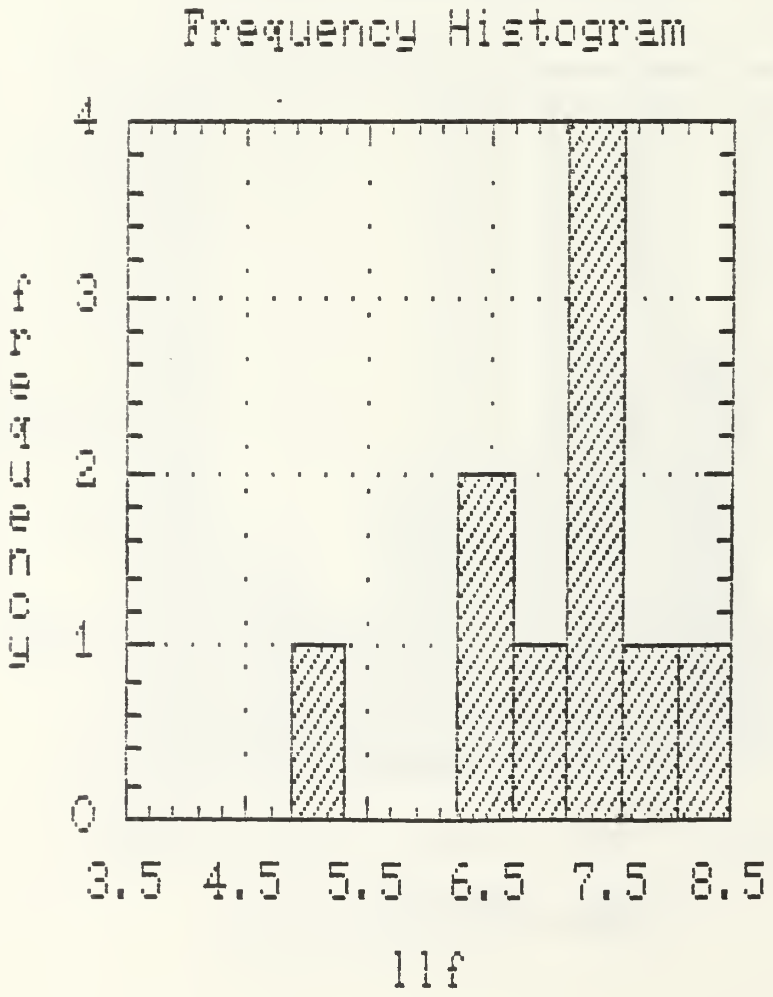
```
                          One-Sample Analysis Results
================================================================================
                                               gtow DIVIDE vol
Sample Statistics: Number of Obs.              10
                   Average                     37.0008
                   Variance                    158.864
                   Std. Deviation .            12.6041
                   Median                      36.313

Confidence Interval for Mean:                  95    Percent
                   Sample 1                    27.9819 46.0197      9 D.F.

Confidence Interval for Variance:              0      Percent
                   Sample 1


Hypothesis Test for HO: Mean = 0               Computed t statistic = 9.2832
                       vs Alt: NE              Sig. Level = 6.6219E-6
                    at Alpha = 0.05            so reject HO.
```



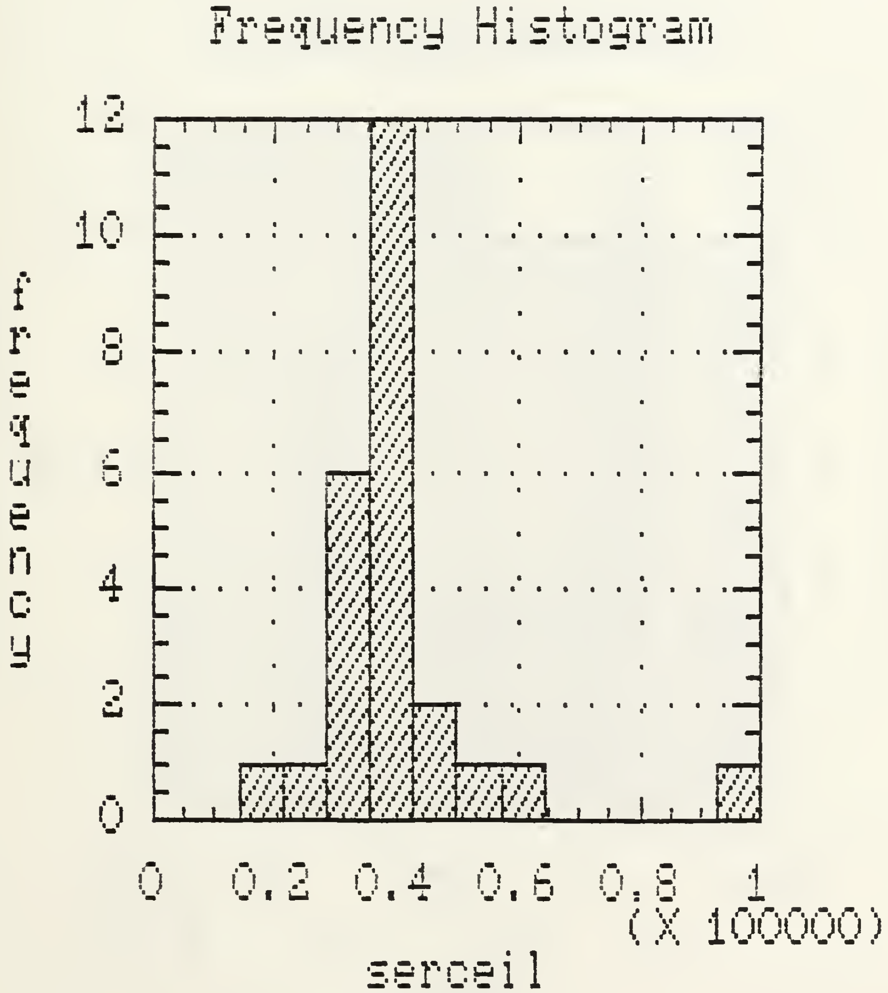
```
                       One-Sample Analysis Results
===========================================================================
                                             gtow DIVIDE ws
Sample Statistics: Number of Obs.            29
                   Average                   4.02412
                   Variance                  0.747225
                   Std. Deviation            0.864422
                   Median                    3.86238

Confidence Interval for Mean:                95    Percent
                   Sample 1                  3.69524 4.35301     28 D.F.

Confidence Interval for Variance:            0      Percent
                   Sample 1


Hypothesis Test for HO: Mean = 0             Computed t statistic = 25.0694
                       vs Alt: NE            Sig. Level = 0
                     at Alpha = 0.05         so reject HO.
```



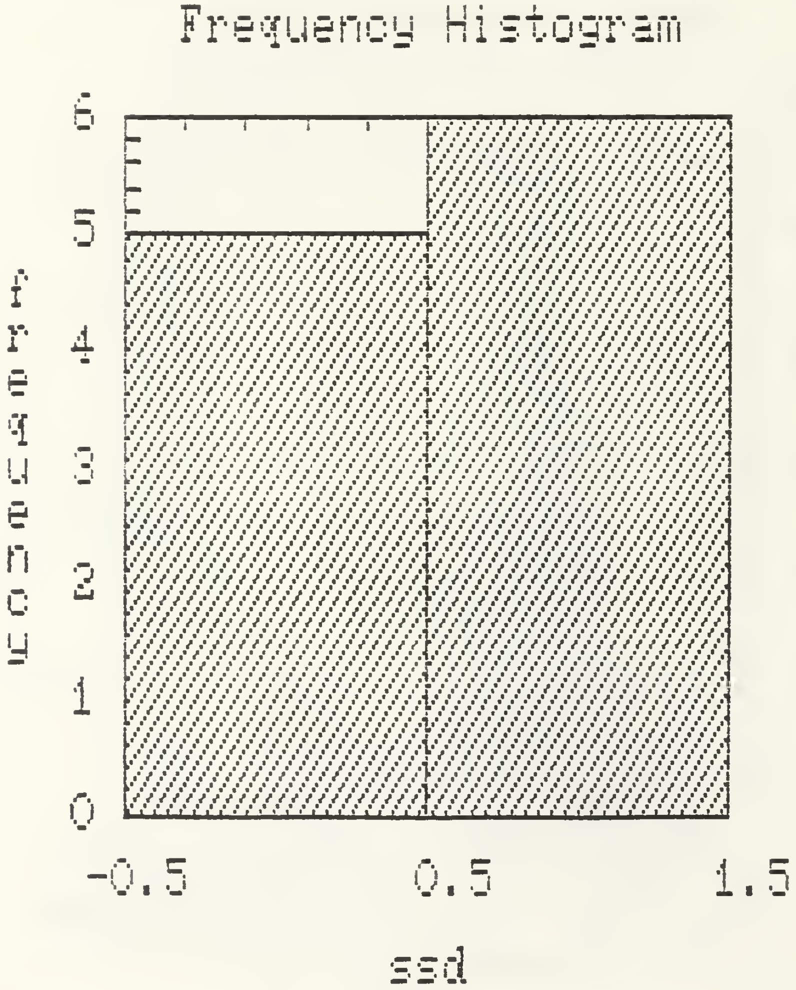
```
                         One-Sample Analysis Results

                                          llf
Sample Statistics: Number of Obs.         11
                   Average                6.77264
                   Variance               2.0014
                   Std. Deviation         1.41471
                   Median                 7.333

Confidence Interval for Mean:             95    Percent
                   Sample 1               5.82197 7.7233     10 D.F.

Confidence Interval for Variance:         0      Percent
                   Sample 1


Hypothesis Test for HO: Mean = 0          Computed t statistic = 15.8777
                     vs Alt: NE           Sig. Level = 2.02201E-8
                   at Alpha = 0.05        so reject HO.
```



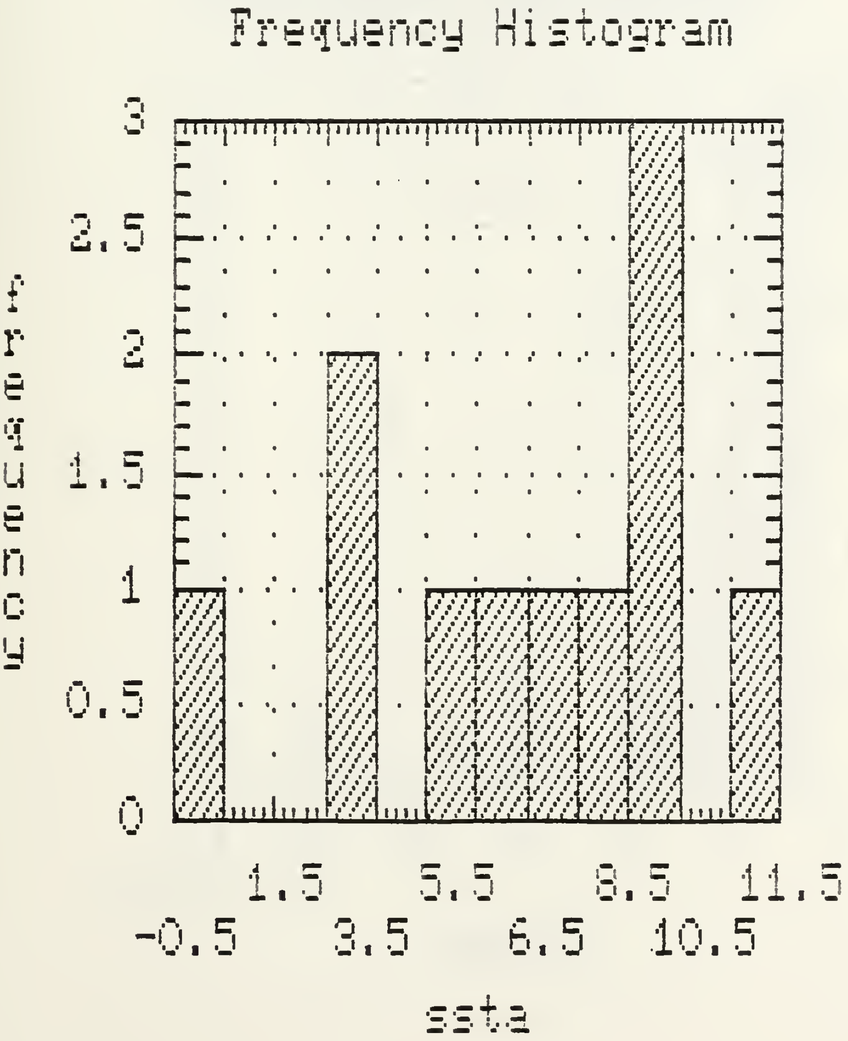
```
                        One-Sample Analysis Results

                                          serceil
Sample Statistics: Number of Obs.         25
                   Average                41018.8
                   Variance               2.23502E8
                   Std. Deviation         14950
                   Median                 38820

Confidence Interval for Mean:             95     Percent
                   Sample 1               34846.3 47191.3     24 D.F.

Confidence Interval for Variance:         0      Percent
                   Sample 1


Hypothesis Test for HO: Mean = 0          Computed t statistic = 13.7187
                       vs Alt: NE         Sig. Level = 7.4607E-13
                    at Alpha = 0.05       so reject HO.
```



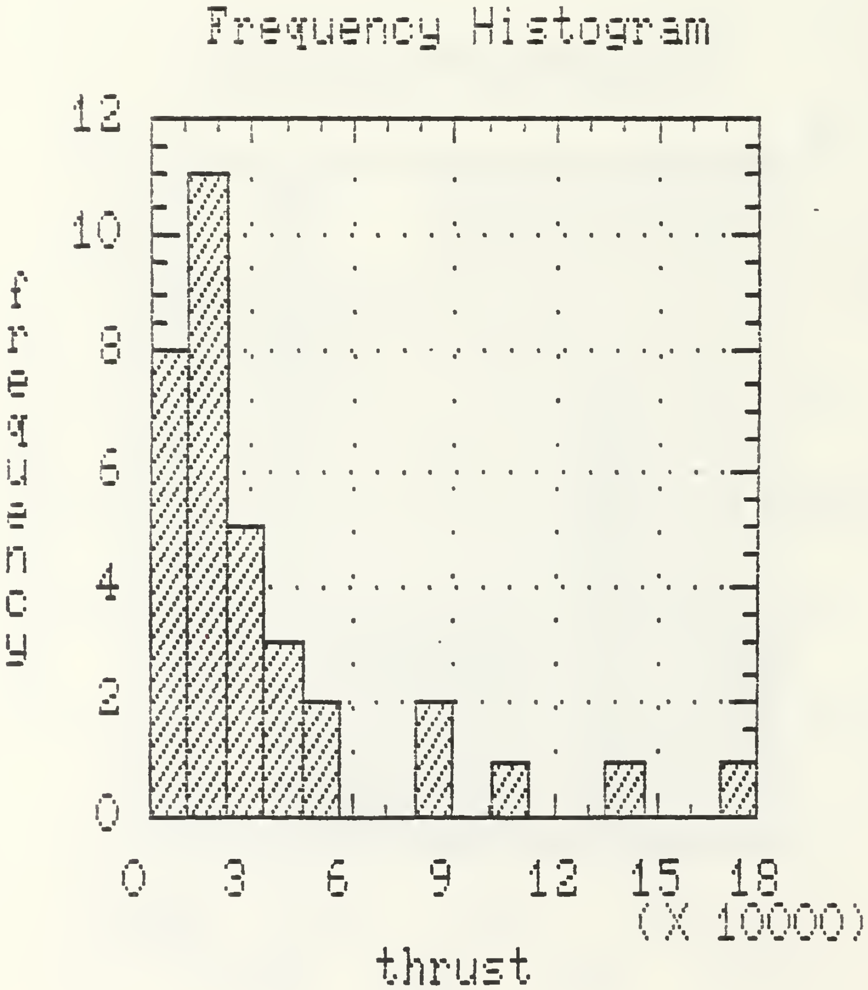
```
                            One-Sample Analysis Results
===================================================================================
                                          ssd
Sample Statistics: Number of Obs.         11
                   Average                0.545455
                   Variance               0.272727
                   Std. Deviation         0.522233
                   Median                 1

Confidence Interval for Mean:             95    Percent
                   Sample 1               0.19452 0.896389     10 D.F.

Confidence Interval for Variance:         0      Percent
                   Sample 1


Hypothesis Test for HO: Mean = 0          Computed t statistic = 3.4641
                       vs Alt: NE         Sig. Level = 6.08085E-3
                    at Alpha = 0.05       so reject HO.
```

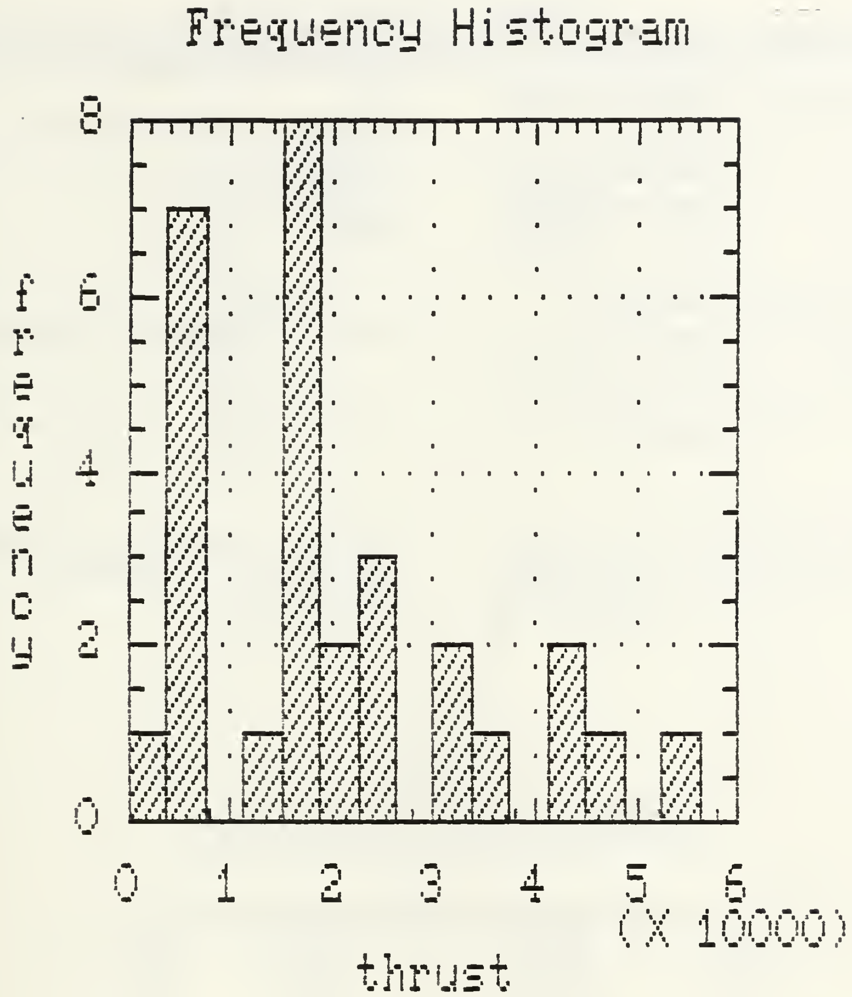


```
                         One-Sample Analysis Results
=============================================================================

                                          ssta
Sample Statistics: Number of Obs.         11
                   Average                6.36364
                   Variance               11.0545
                   Std. Deviation         3.32484
                   Median                 7

Confidence Interval for Mean:             95     Percent
                   Sample 1               4.12938 8.59789     10 D.F.

Confidence Interval for Variance:         0       Percent
                   Sample 1


Hypothesis Test for HO: Mean = 0          Computed t statistic = 6.34792
                       vs Alt: NE         Sig. Level = 8.37422E-5
                    at Alpha = 0.05       so reject HO.
```

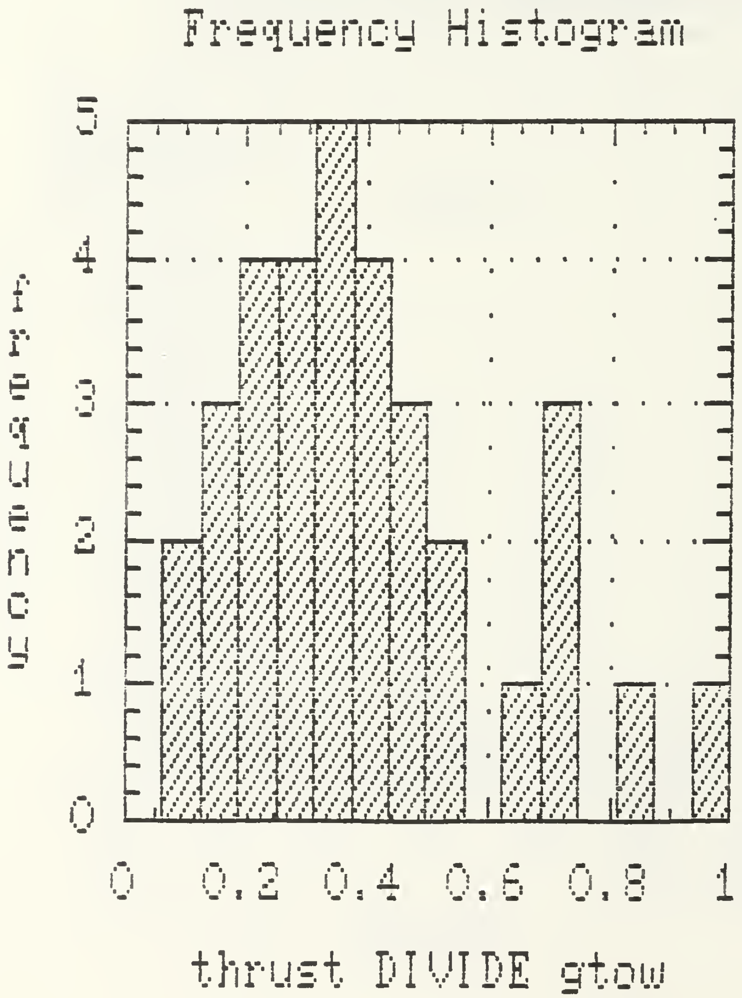


```
                       One-Sample Analysis Results
==========================================================================
                                              thrust
Sample Statistics: Number of Obs.             34
                   Average                    34756.5
                   Variance                   1.54224E9
                   Std. Deviation             39271.4
                   Median                     19415

Confidence Interval for Mean:                 95     Percent
                   Sample 1                   21050.8 48462.1     33 D.F.

Confidence Interval for Variance:             0       Percent
                   Sample 1


Hypothesis Test for H0: Mean = 0              Computed t statistic = 5.16059
                       vs Alt: NE             Sig. Level = 1.17766E-5
                    at Alpha = 0.05           so reject H0.
```

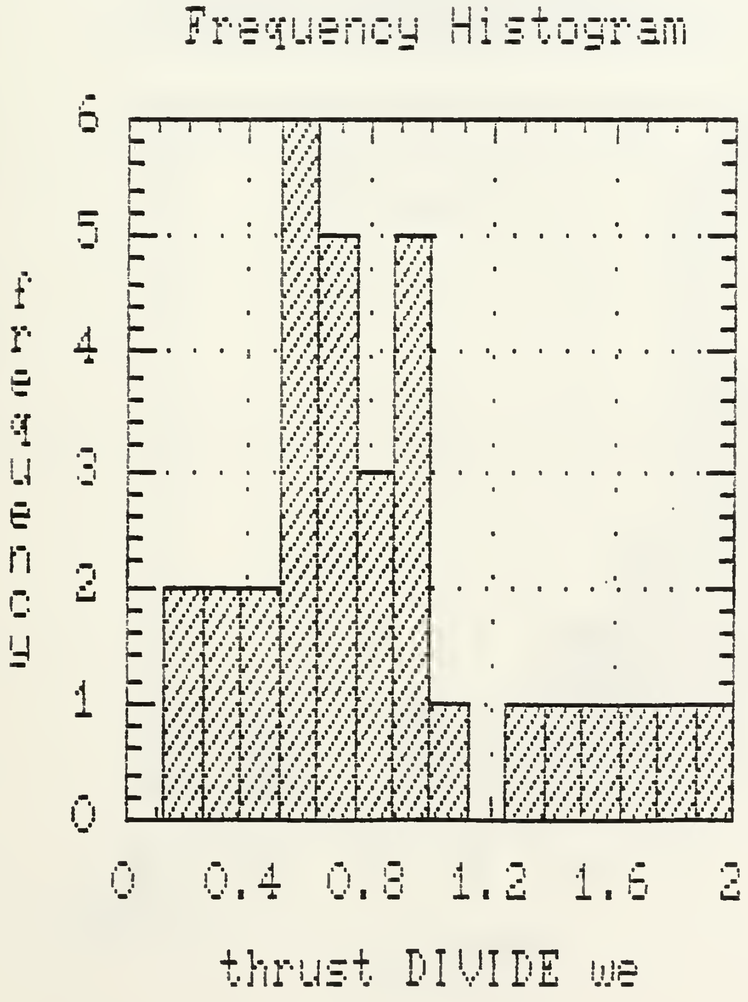



Frequency Histogram
frequency
0
2
4
6
8
0
1
2
3
4
5
6
(X 10000)
thrust

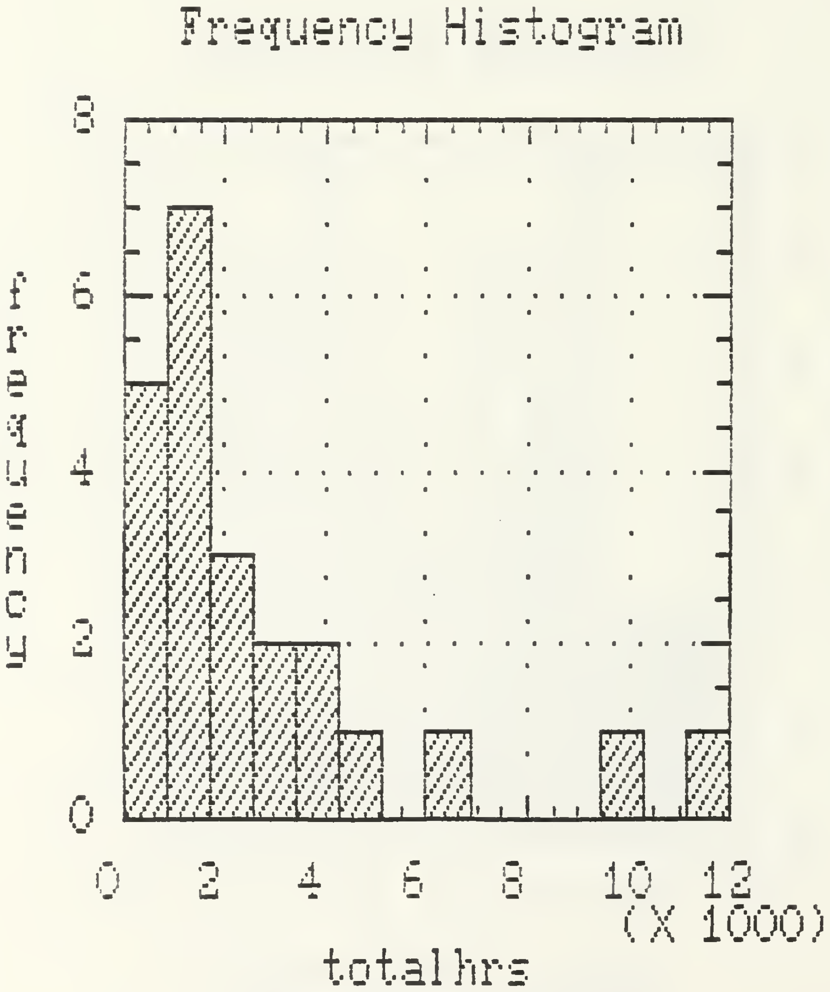
```
                         One-Sample Analysis Results
==========================================================================
                                            thrust DIVIDE gtow
Sample Statistics: Number of Obs.           33
                   Average                  0.391425
                   Variance                 0.0483744
                   Std. Deviation           0.219942
                   Median                   0.345

Confidence Interval for Mean:               95    Percent
                   Sample 1                 0.313419 0.469431     32 D.F.

Confidence Interval for Variance:           0      Percent
                   Sample 1


Hypothesis Test for H0: Mean = 0            Computed t statistic = 10.2235
                        vs Alt: NE          Sig. Level = 1.31655E-11
                    at Alpha = 0.05         so reject H0.
```

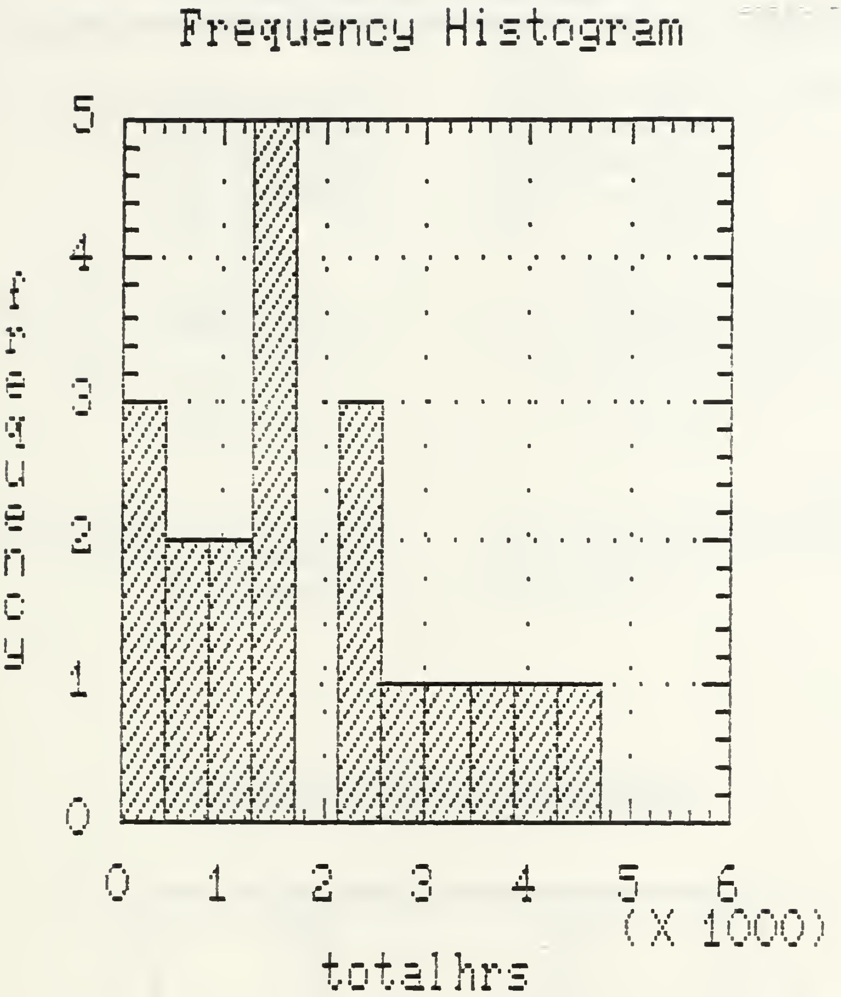


```
                          One-Sample Analysis Results
================================================================================
                                          thrust DIVIDE we
Sample Statistics: Number of Obs.         32
                   Average                0.826883
                   Variance               0.200047
                   Std. Deviation         0.447267
                   Median                 0.703102

Confidence Interval for Mean:             95    Percent
                   Sample 1               0.665588 0.988177     31 D.F.

Confidence Interval for Variance:         0      Percent
                   Sample 1


Hypothesis Test for HO: Mean = 0          Computed t statistic = 10.4581
                       vs Alt: NE         Sig. Level = 1.08784E-11
                    at Alpha = 0.05       so reject HO.
```

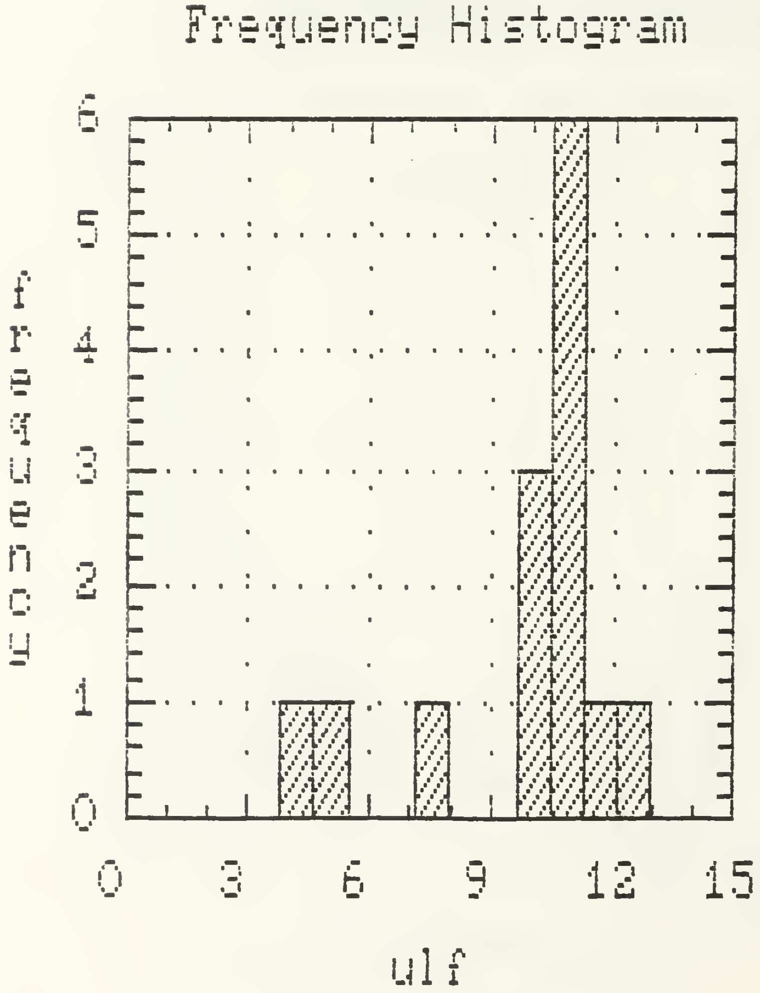


```
                    One-Sample Analysis Results
=======================================================================
                                          totalhrs
Sample Statistics: Number of Obs.         23
                   Average                2827.24
                   Variance               8.64743E6
                   Std. Deviation         2940.65
                   Median                 1555

Confidence Interval for Mean:             95    Percent
                   Sample 1               1555.3 4099.17     22 D.F.

Confidence Interval for Variance:         0      Percent
                   Sample 1


Hypothesis Test for H0: Mean = 0          Computed t statistic = 4.61087
                     vs Alt: NE           Sig. Level = 1.35702E-4
                  at Alpha = 0.05         so reject H0.
```

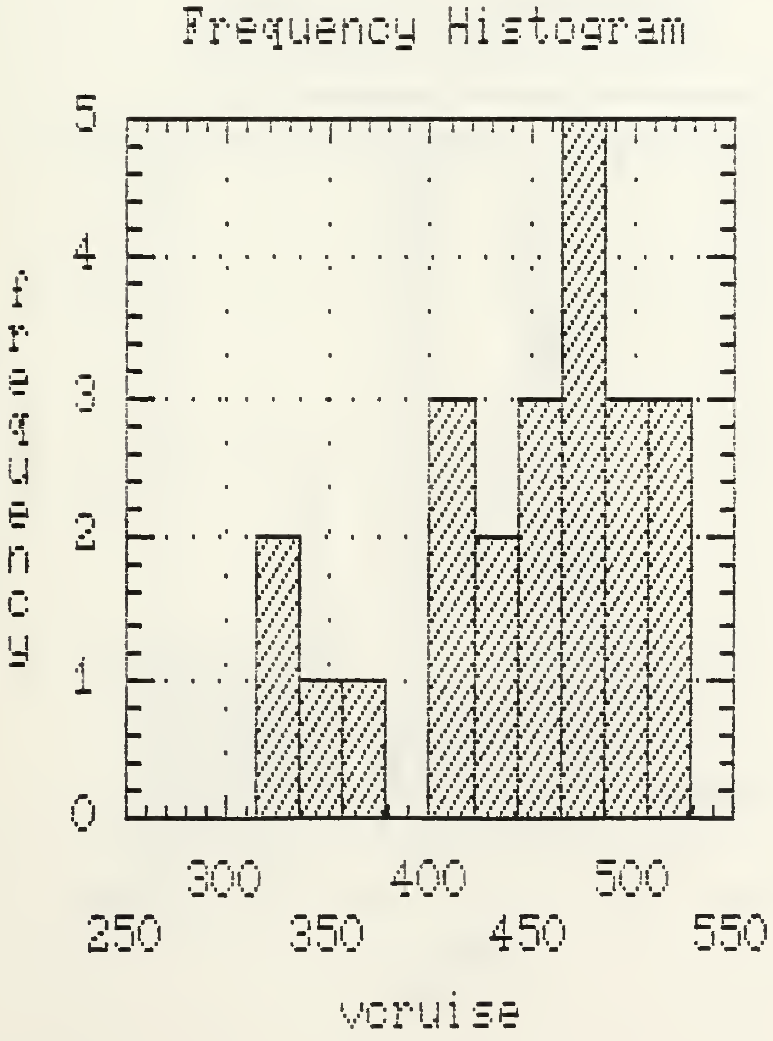



Frequency Histogram
frequency
0
1
2
3
4
5
0
1
2
3
4
5
6
(X 1000)
totalhrs

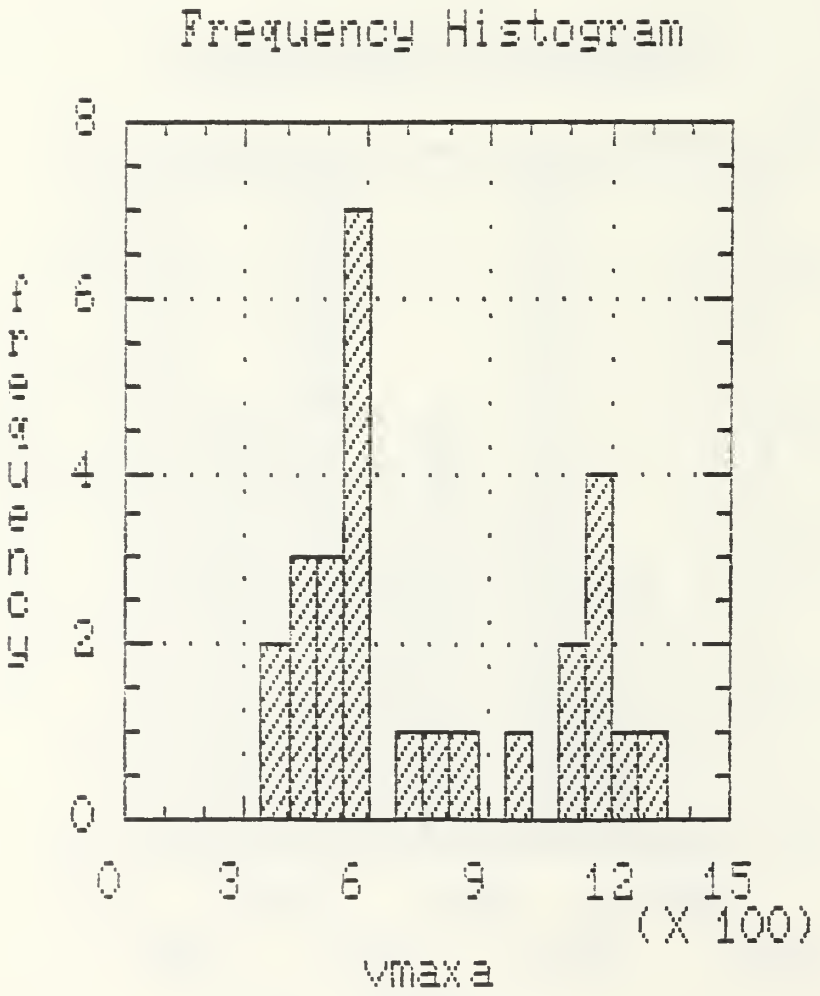
```
                              One-Sample Analysis Results
=========================================================================================
                                          ulf
Sample Statistics: Number of Obs.         14
                   Average                9.74214
                   Variance               6.3674
                   Std. Deviation         2.52337
                   Median                 10.75

Confidence Interval for Mean:             95    Percent
                   Sample 1               8.28482 11.1995     13 D.F.

Confidence Interval for Variance:         0      Percent
                   Sample 1


Hypothesis Test for H0: Mean = 0          Computed t statistic = 14.4457
                       vs Alt: NE         Sig. Level = 2.19486E-9
                   at Alpha = 0.05        so reject H0.
```



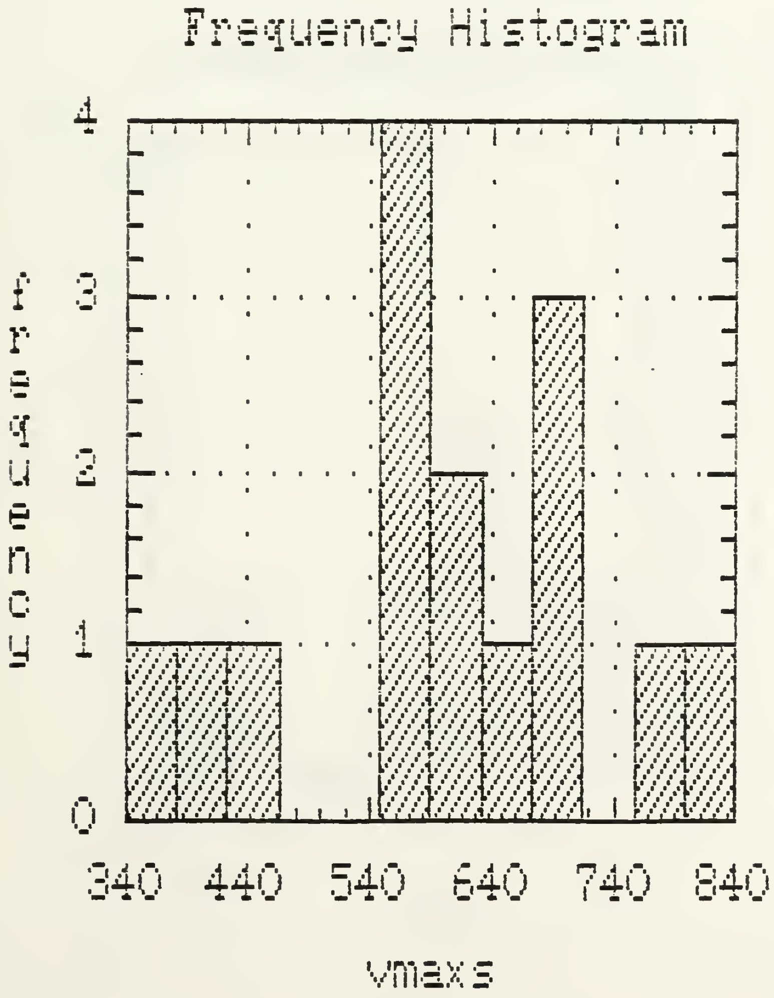
```
                              One-Sample Analysis Results
==========================================================================================
                                            vcruise
Sample Statistics: Number of Obs.           24
                   Average                  437.542
                   Variance                 4698.78
                   Std. Deviation           68.5477
                   Median                   451.5

Confidence Interval for Mean:               95     Percent
                   Sample 1                 408.59 466.494     23 D.F.

Confidence Interval for Variance:           0       Percent
                   Sample 1


Hypothesis Test for HO: Mean = 0            Computed t statistic = 31.2703
                       vs Alt: NE           Sig. Level = 0
                    at Alpha = 0.05         so reject HO.
```



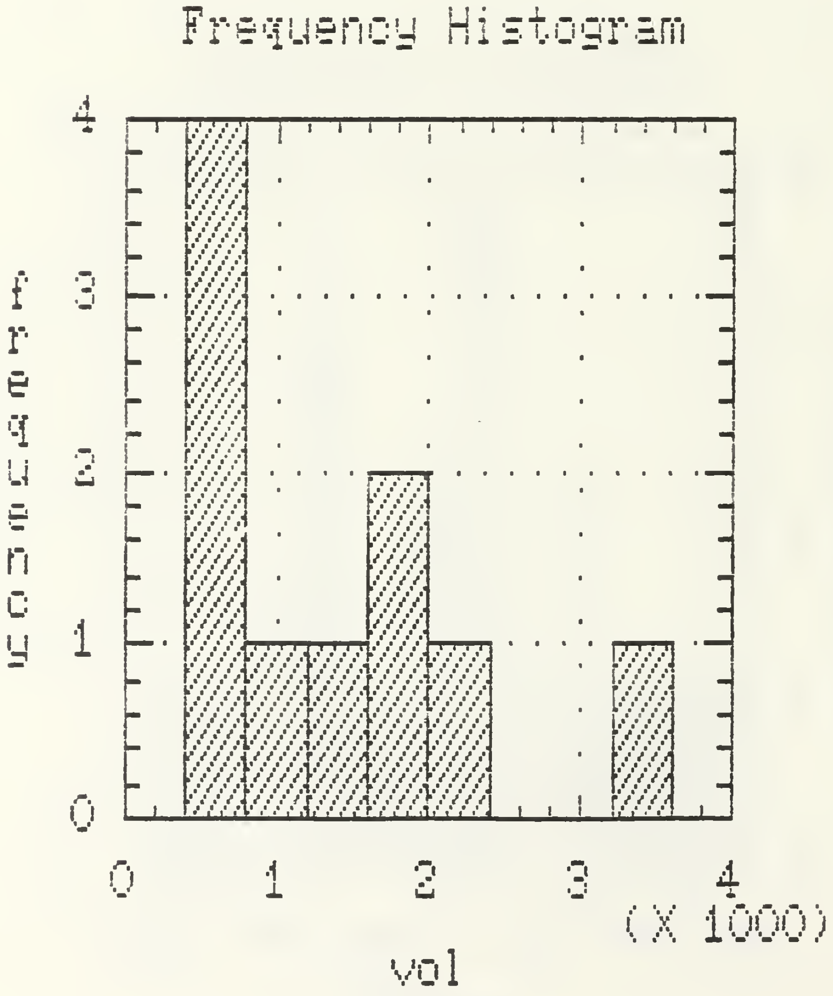
```
                          One-Sample Analysis Results
==============================================================================
                                                    vmaxa
Sample Statistics: Number of Obs.                   27
                   Average                          754.593
                   Variance                         101210
                   Std. Deviation                   318.135
                   Median                           602

Confidence Interval for Mean:                       95     Percent
                   Sample 1                         626.713 880.472      26 D.F.

Confidence Interval for Variance:                   0       Percent
                   Sample 1


Hypothesis Test for HO: Mean = 0                    Computed t statistic = 12.3249
                       vs Alt: NE                   Sig. Level = 2.31348E-12
                     at Alpha = 0.05                so reject HO.
```



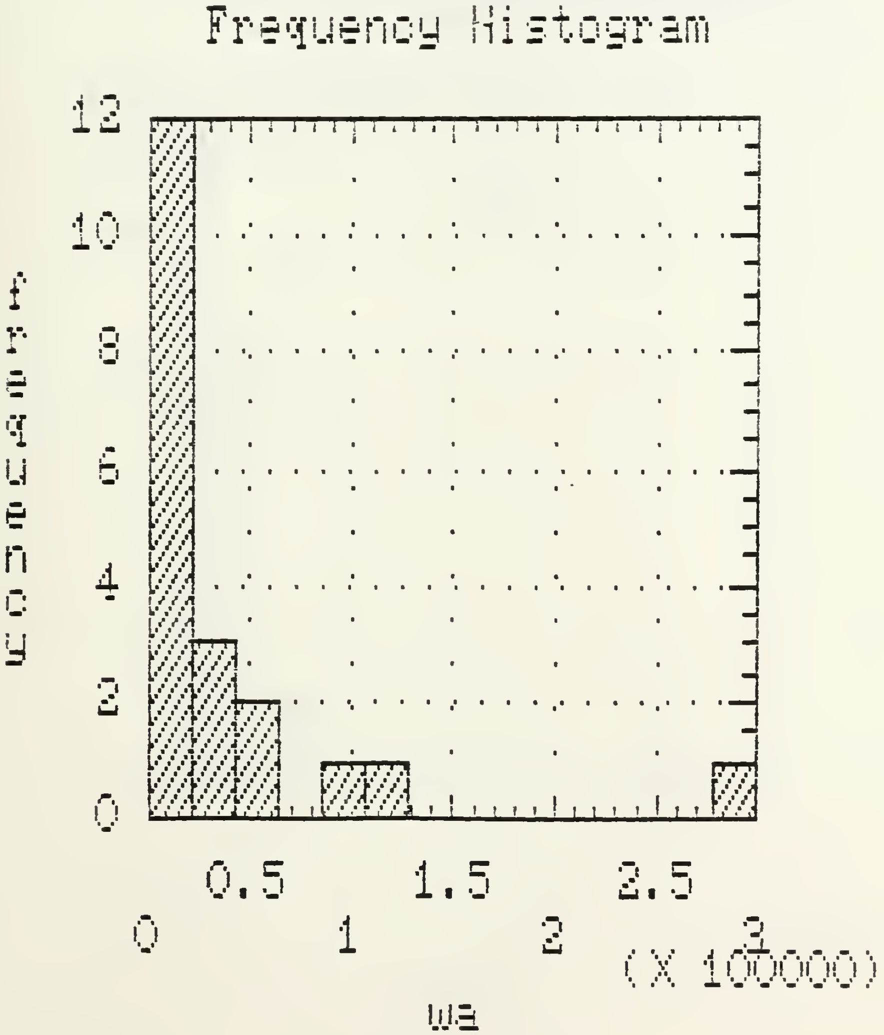
```
                          One-Sample Analysis Results
=================================================================================
                                             vmaxs
Sample Statistics: Number of Obs.            15
                   Average                   600.467
                   Variance                  17782.1
                   Std. Deviation            133.35
                   Median                    602

Confidence Interval for Mean:                95     Percent
                   Sample 1                  526.601 674.332      14 D.F.

Confidence Interval for Variance:            0       Percent
                   Sample 1


Hypothesis Test for HO: Mean = 0             Computed t statistic = 17.4396
                        vs Alt: NE           Sig. Level = 6.8257E-11
                     at Alpha = 0.05         so reject HO.
```



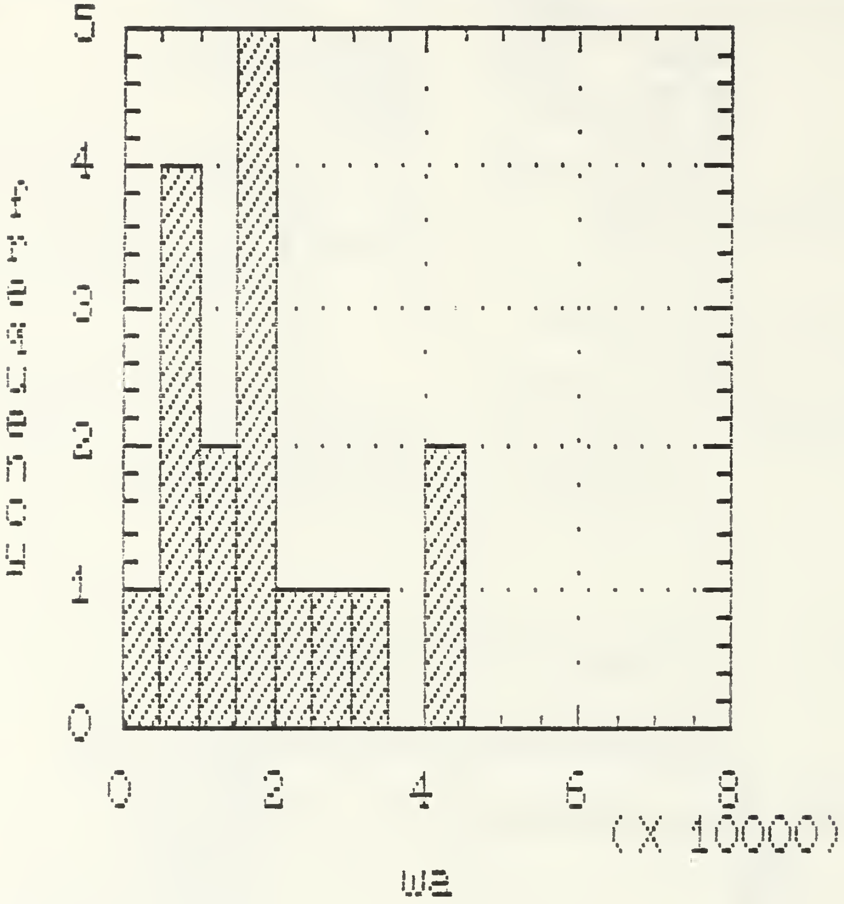
```
                         One-Sample Analysis Results
==========================================================================
                                            vol
Sample Statistics: Number of Obs.           10
                   Average                  1370.4
                   Variance                 804927
                   Std. Deviation           897.177
                   Median                   1163.5

Confidence Interval for Mean:               95    Percent
                   Sample 1                 728.423 2012.38      9 D.F.

Confidence Interval for Variance:           0      Percent
                   Sample 1


Hypothesis Test for H0: Mean = 0            Computed t statistic = 4.83024
                       vs Alt: NE           Sig. Level = 9.33588E-4
                    at Alpha = 0.05         so reject H0.
```



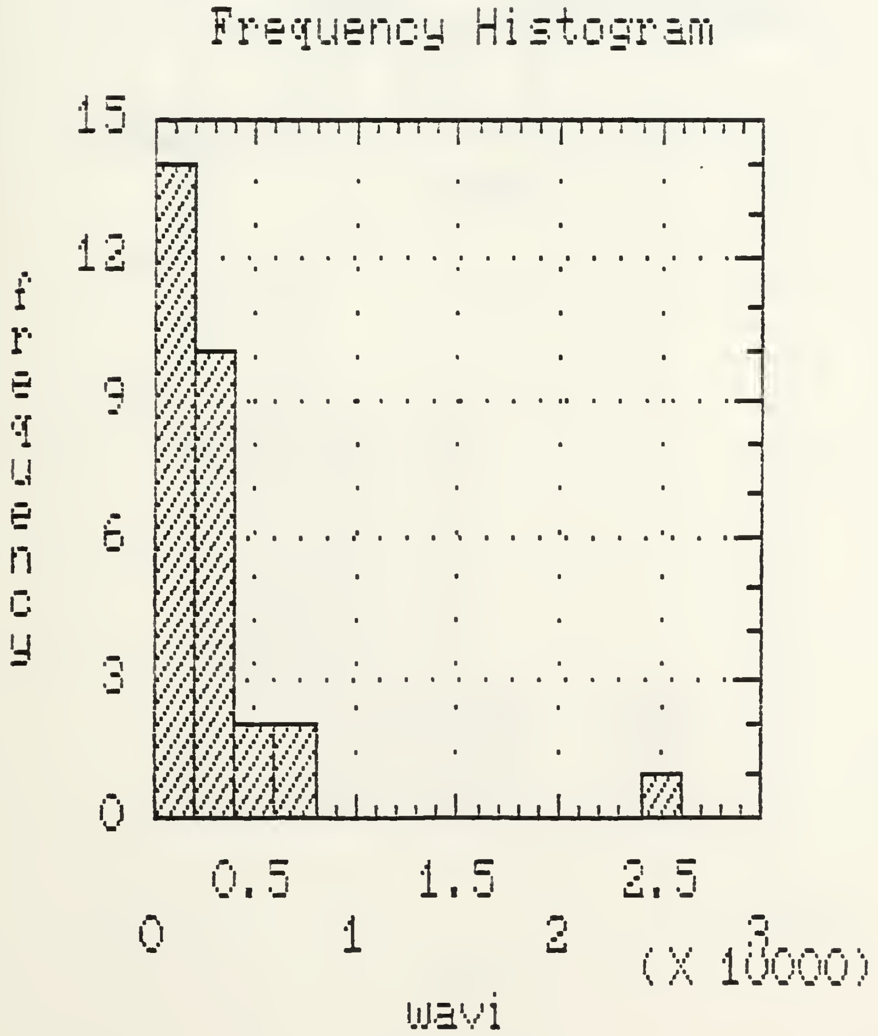
```
                         One-Sample Analysis Results
==============================================================================
                                              wa
Sample Statistics: Number of Obs.             20
                   Average                    41146
                   Variance                   4.21295E9
                   Std. Deviation             64907.2
                   Median                     17000.5

Confidence Interval for Mean:                 95    Percent
                   Sample 1                   10761 71530.9     19 D.F.

Confidence Interval for Variance:             0      Percent
                   Sample 1


Hypothesis Test for H0: Mean = 0              Computed t statistic = 2.83497
                       vs Alt: NE             Sig. Level = 0.0105845
                    at Alpha = 0.05           so reject H0.
```

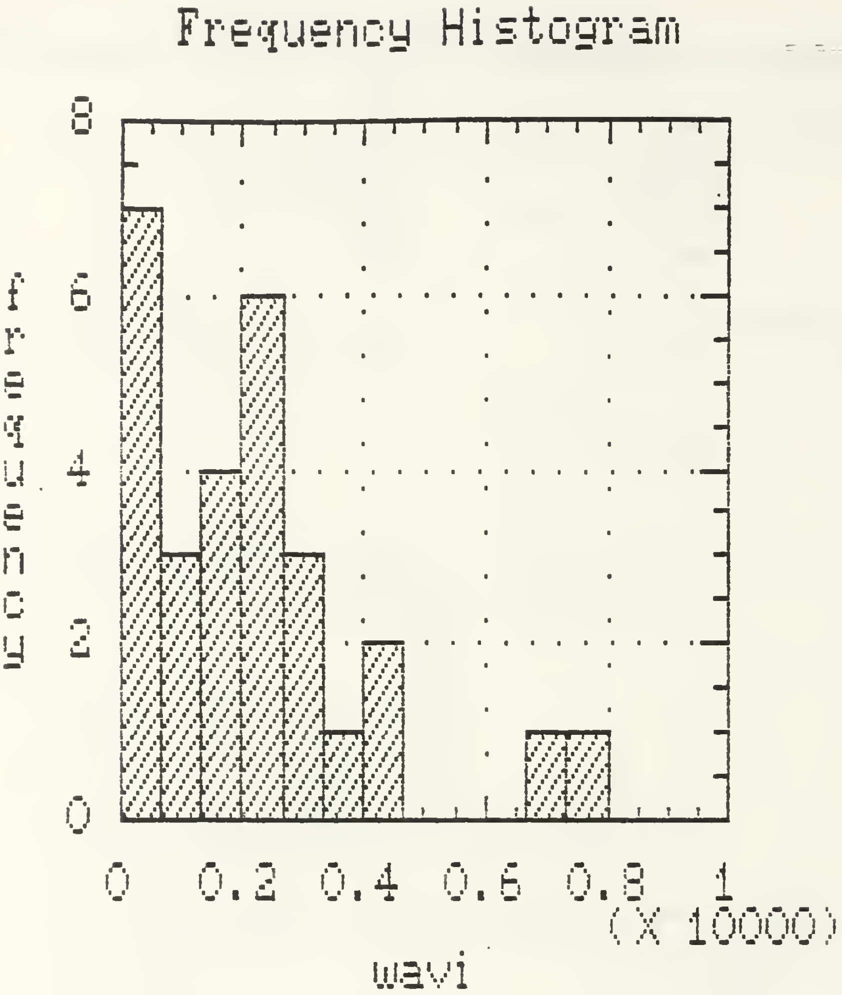


Frequency Histogram

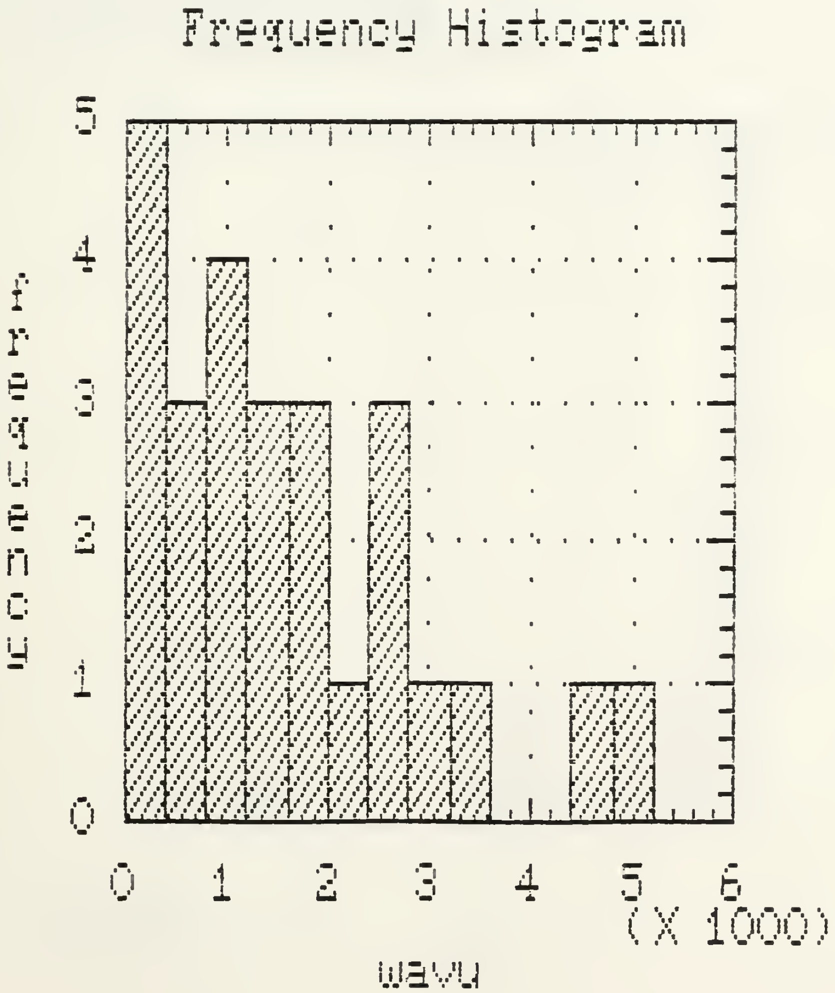


```
                          One-Sample Analysis Results
================================================================================
                                               wavi
Sample Statistics: Number of Obs.              29
                   Average                     2959.28
                   Variance                    2.22048E7
                   Std. Deviation              4712.2
                   Median                      2016

Confidence Interval for Mean:                  95    Percent
                   Sample 1                    1166.43 4752.12     28 D.F.

Confidence Interval for Variance:              0      Percent
                   Sample 1


Hypothesis Test for HO: Mean = 0               Computed t statistic = 3.3819
                        vs Alt: NE             Sig. Level = 2.14005E-3
                    at Alpha = 0.05            so reject HO.
```

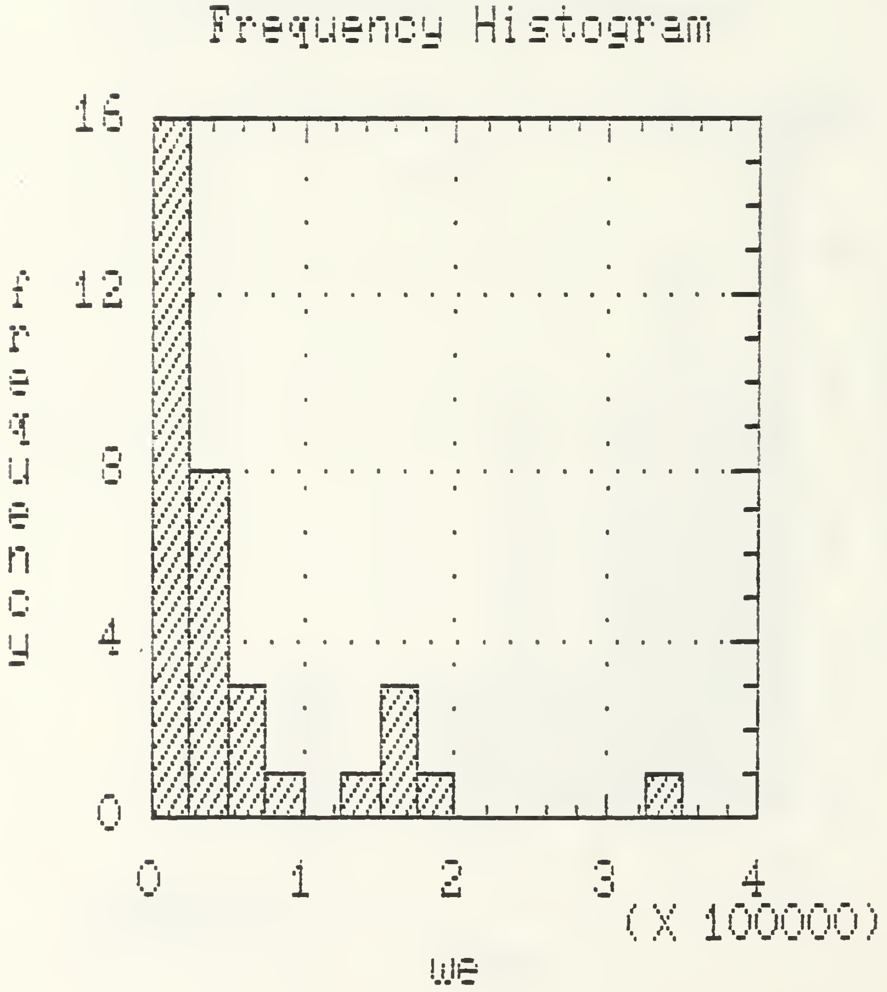


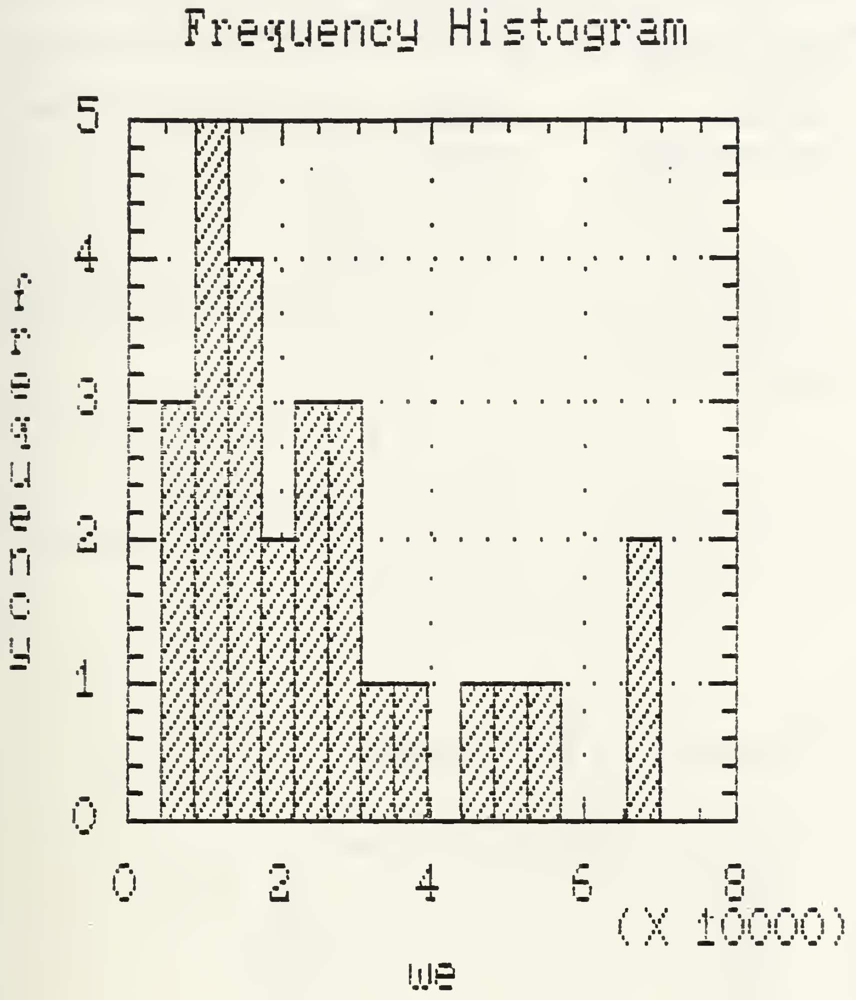

Frequency Histogram
frequency
0
2
4
6
8
0
0.2
0.4
0.6
0.8
1
(X 10000)
wavi

```
                          One-Sample Analysis Results
================================================================================
                                             wavu
Sample Statistics: Number of Obs.            26
                   Average                   1595.23
                   Variance                  1.78913E6
                   Std. Deviation            1337.58
                   Median                    1355

Confidence Interval for Mean:                95    Percent
                   Sample 1                  1054.84 2135.62     25 D.F.

Confidence Interval for Variance:            0      Percent
                   Sample 1


Hypothesis Test for HO: Mean = 0             Computed t statistic = 6.0812
                       vs Alt: NE            Sig. Level = 2.35225E-6
                    at Alpha = 0.05          so reject HO.
```

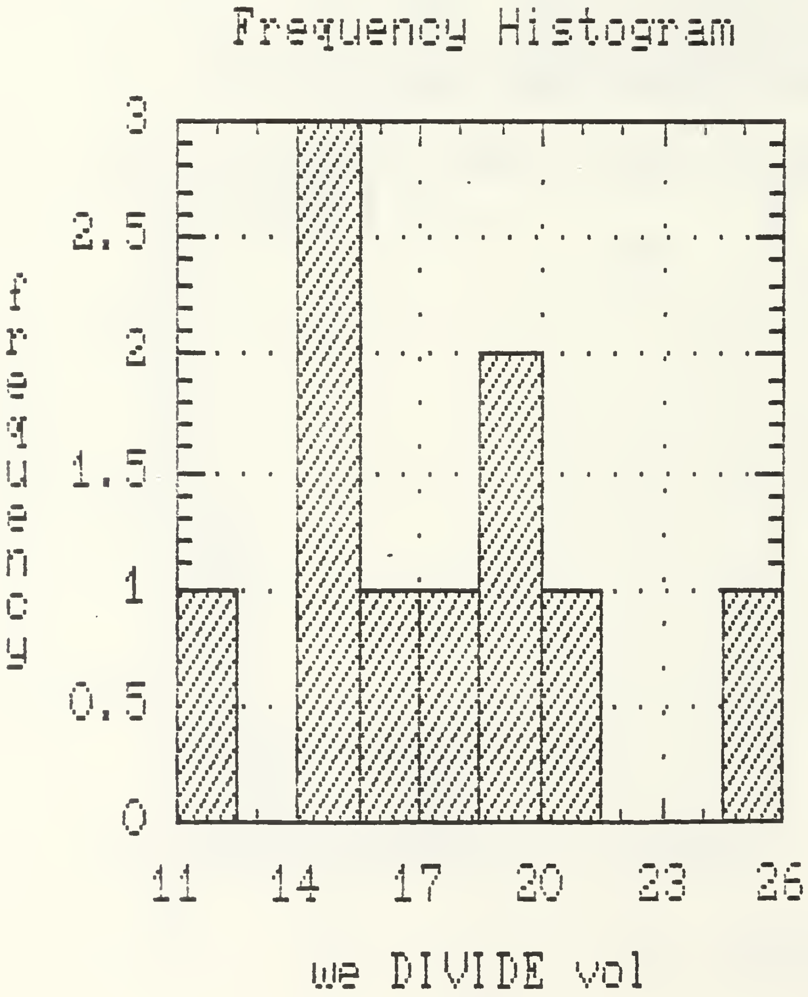


```
                       One-Sample Analysis Results
=====================================================================================

                                            we
Sample Statistics: Number of Obs.           34
                   Average                  56357.6
                   Variance                 5.09945E9
                   Std. Deviation           71410.4
                   Median                   25906

Confidence Interval for Mean:               95     Percent
                   Sample 1                 31435.5 81279.6      33 D.F.

Confidence Interval for Variance:           0       Percent
                   Sample 1


Hypothesis Test for HO: Mean = 0            Computed t statistic = 4.60182
                       vs Alt: NE           Sig. Level = 5.9478E-5
                    at Alpha = 0.05         so reject HO.
```

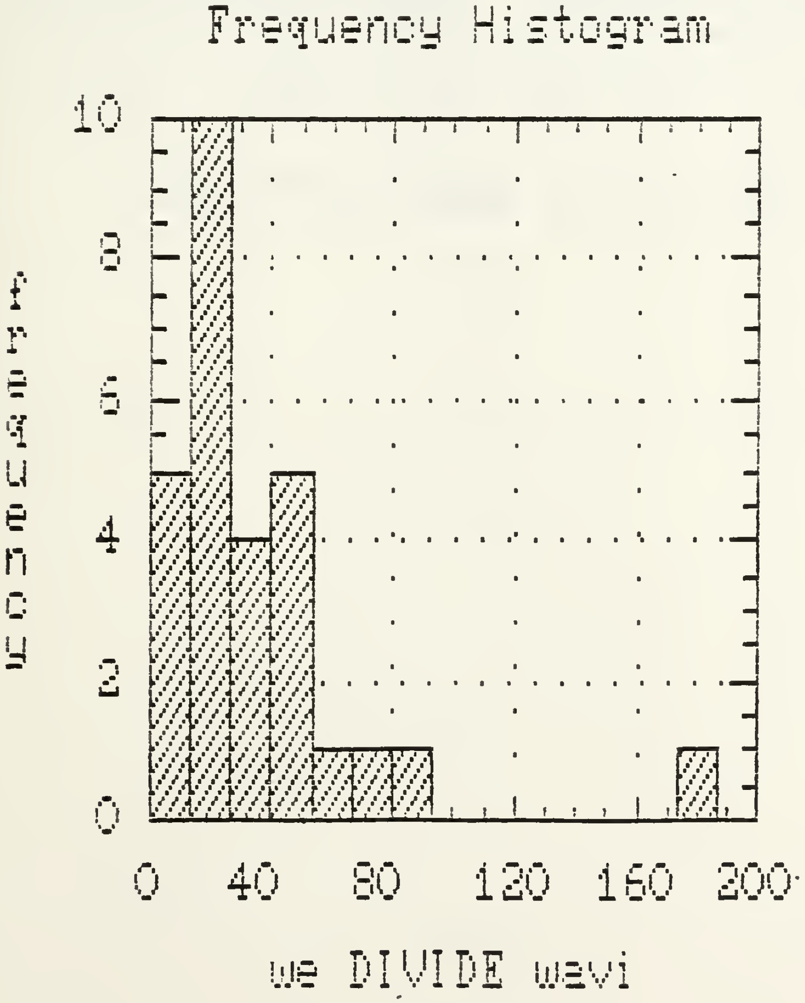


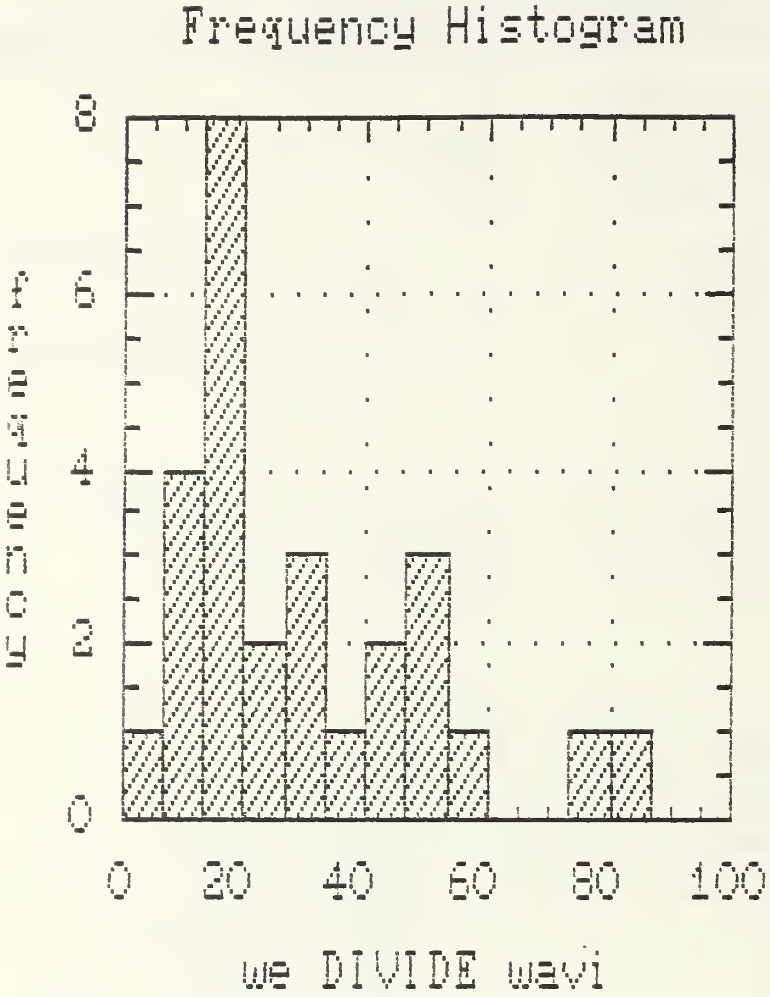

Frequency Histogram
frequency
0
1
2
3
4
5
0
2
4
6
8
(X 10000)
we

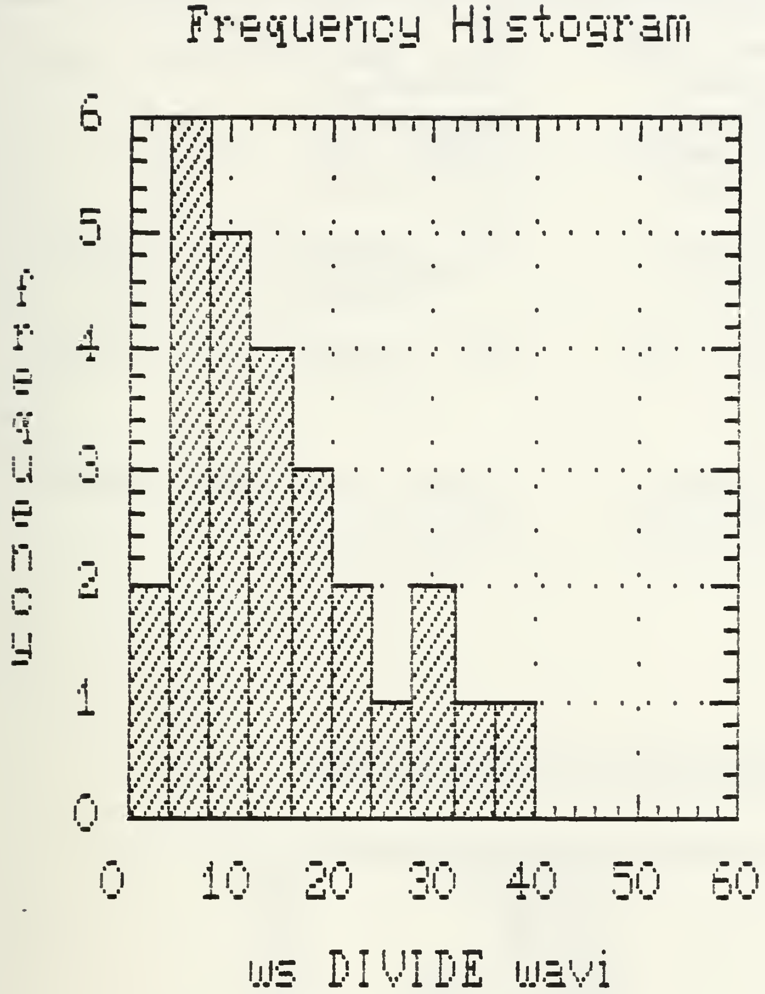
```
                          One-Sample Analysis Results
===============================================================================
                                            we DIVIDE vol
Sample Statistics: Number of Obs.           10
                   Average                  17.563
                   Variance                 17.0068
                   Std. Deviation           4.12393
                   Median                   16.8659

Confidence Interval for Mean:               95    Percent
                   Sample 1                 14.6121 20.5139      9 D.F.

Confidence Interval for Variance:           0      Percent
                   Sample 1


Hypothesis Test for H0: Mean = 0            Computed t statistic = 13.4675
                       vs Alt: NE           Sig. Level = 2.86557E-7
                    at Alpha = 0.05         so reject H0.
```



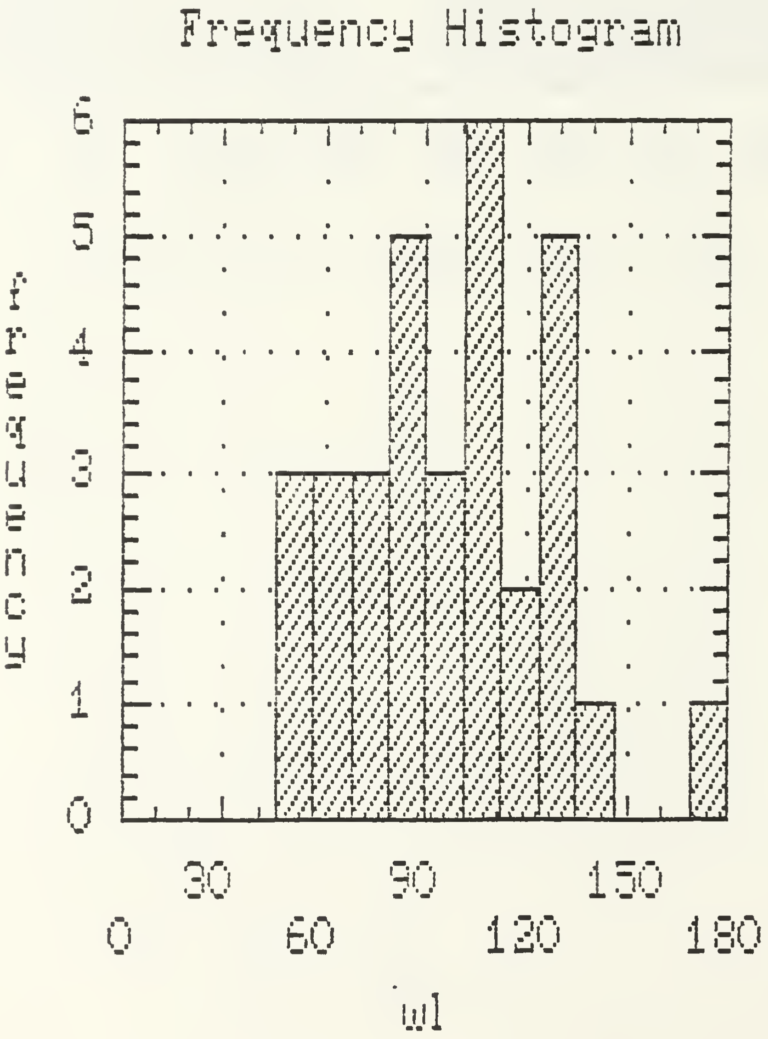
```
                         One-Sample Analysis Results
===============================================================================
                                            we DIVIDE wavi
Sample Statistics: Number of Obs.           28
                   Average                  35.2013
                   Variance                 1260.87
                   Std. Deviation           35.5087
                   Median                   23.8228

Confidence Interval for Mean:               95    Percent
                   Sample 1                 21.4293 48.9734     27 D.F.

Confidence Interval for Variance:           0      Percent
                   Sample 1


Hypothesis Test for H0: Mean = 0            Computed t statistic = 5.2457
                       vs Alt: NE           Sig. Level = 1.57472E-5
                    at Alpha = 0.05         so reject H0.
```



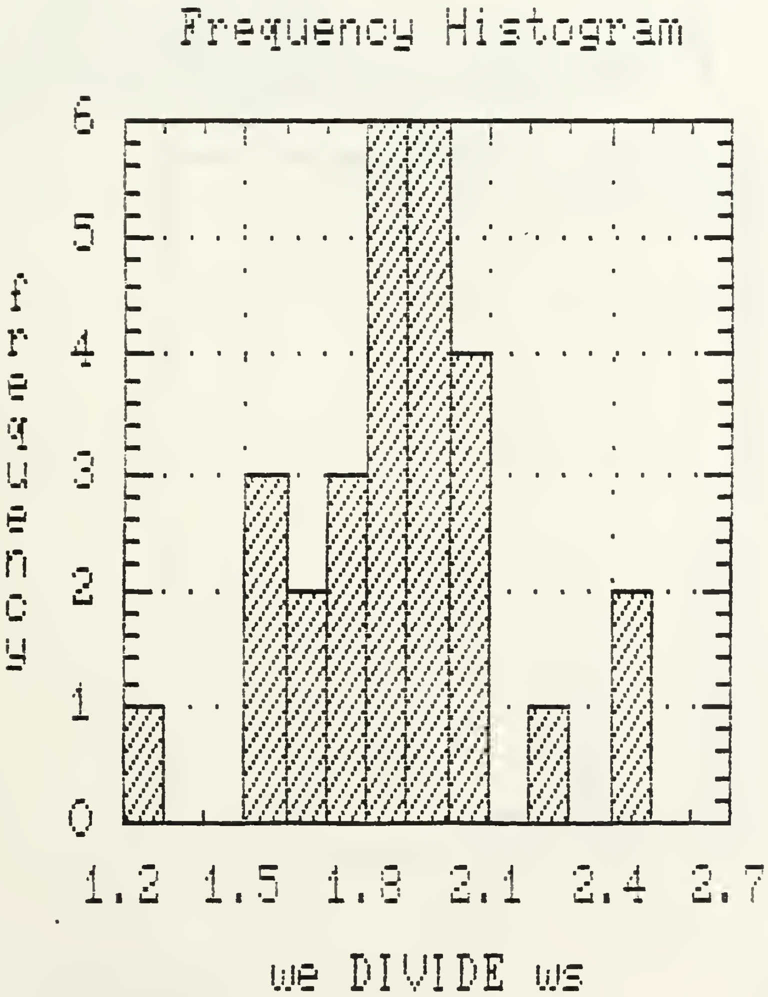

Frequency Histogram
Frequency
0
2
4
6
8
0
20
40
60
80
100
we DIVIDE wavi


Frequency Histogram
FREQUENCY
0
1
2
3
4
5
6
0
10
20
30
40
50
60
ws DIVIDE wavi

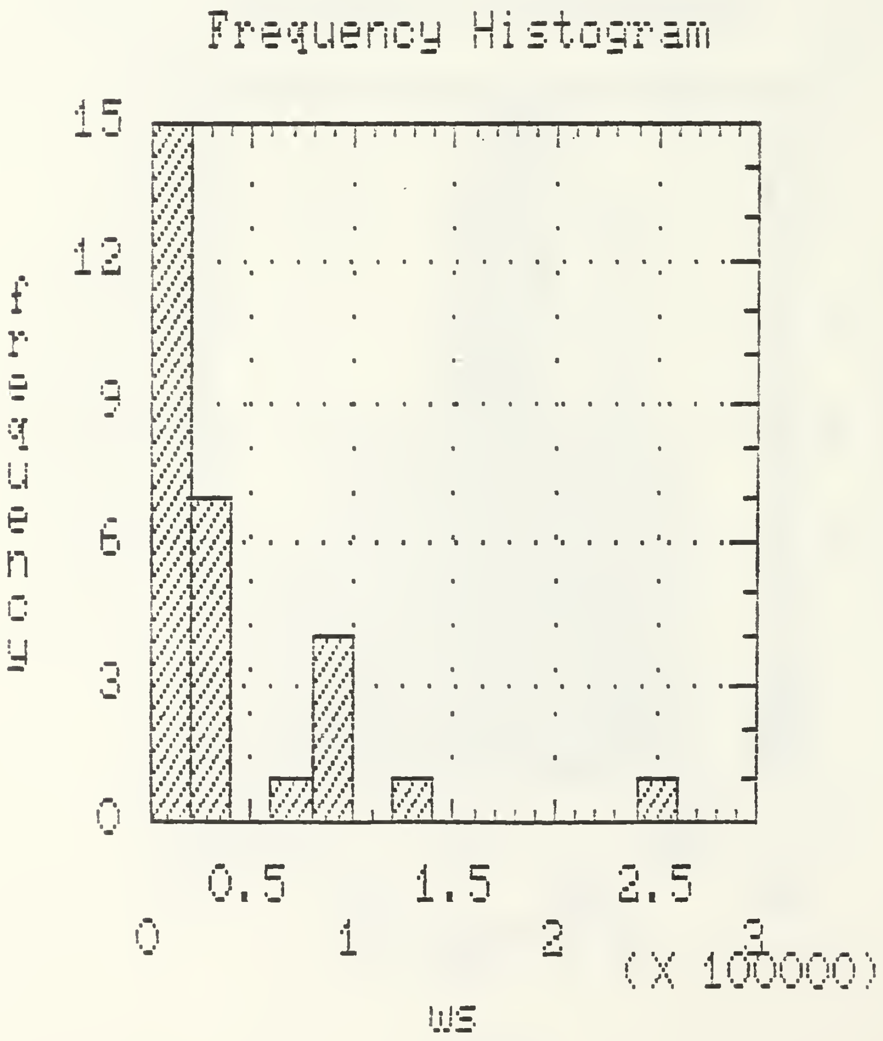
```
                         One-Sample Analysis Results
==============================================================================
                                               wl
Sample Statistics: Number of Obs.              32
                   Average                     98.1719
                   Variance                    896.013
                   Std. Deviation              29.9335
                   Median                      94.95

Confidence Interval for Mean:                  95    Percent
                   Sample 1                    87.3772 108.967     31 D.F.

Confidence Interval for Variance:              0      Percent
                   Sample 1


Hypothesis Test for H0: Mean = 0               Computed t statistic = 18.5526
                       vs Alt: NE              Sig. Level = 0
                    at Alpha = 0.05            so reject H0.
```

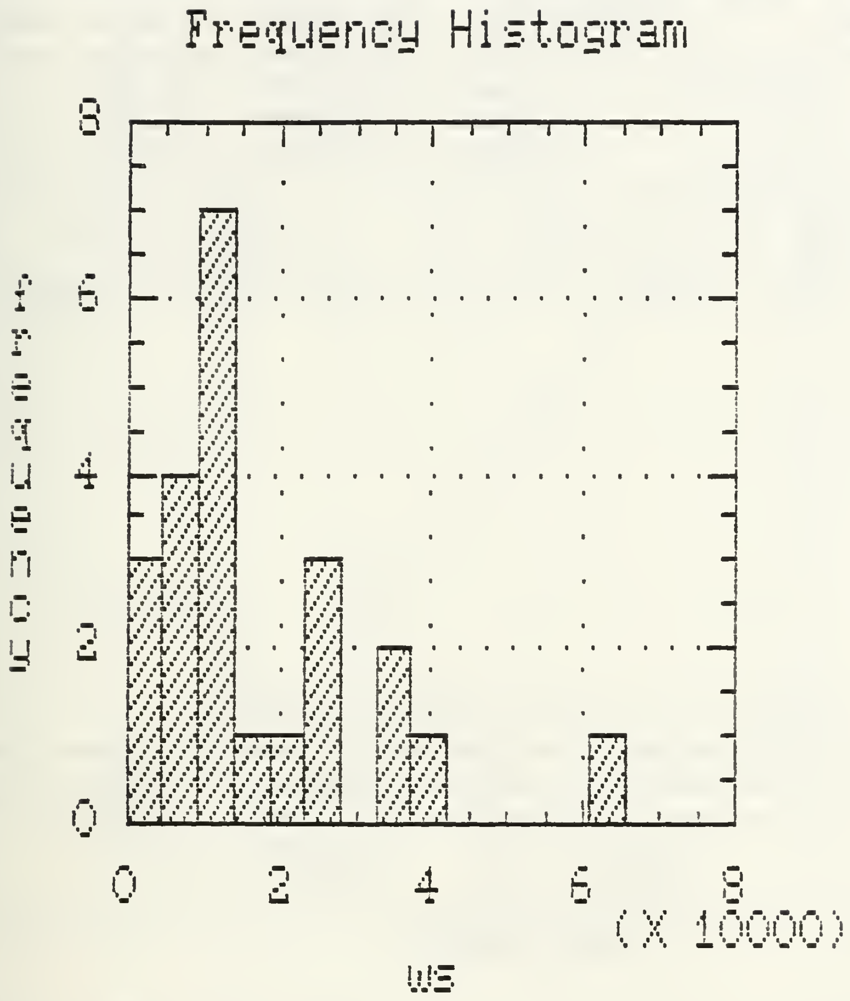


```
                       One-Sample Analysis Results
=======================================================================
                                           we DIVIDE ws
Sample Statistics: Number of Obs.          28
                   Average                 1.87446
                   Variance                0.070027
                   Std. Deviation          0.264626
                   Median                  1.8928

Confidence Interval for Mean:              95    Percent
                   Sample 1                1.77183 1.9771     27 D.F.

Confidence Interval for Variance:          0      Percent
                   Sample 1


Hypothesis Test for HO: Mean = 0           Computed t statistic = 37.4821
                       vs Alt: NE          Sig. Level = 0
                    at Alpha = 0.05        so reject HO.
```



```
                            One-Sample Analysis Results
==============================================================================
                                                  ws
Sample Statistics: Number of Obs.                 29
                   Average                        40255
                   Variance                       2.94592E9
                   Std. Deviation                 54276.3
                   Median                         17801

Confidence Interval for Mean:                     95    Percent
                   Sample 1                       19604.5 60905.5     28 D.F.

Confidence Interval for Variance:                 0      Percent
                   Sample 1


Hypothesis Test for H0: Mean = 0                  Computed t statistic = 3.99401
                       vs Alt: NE                 Sig. Level = 4.27014E-4
                    at Alpha = 0.05               so reject H0.
```

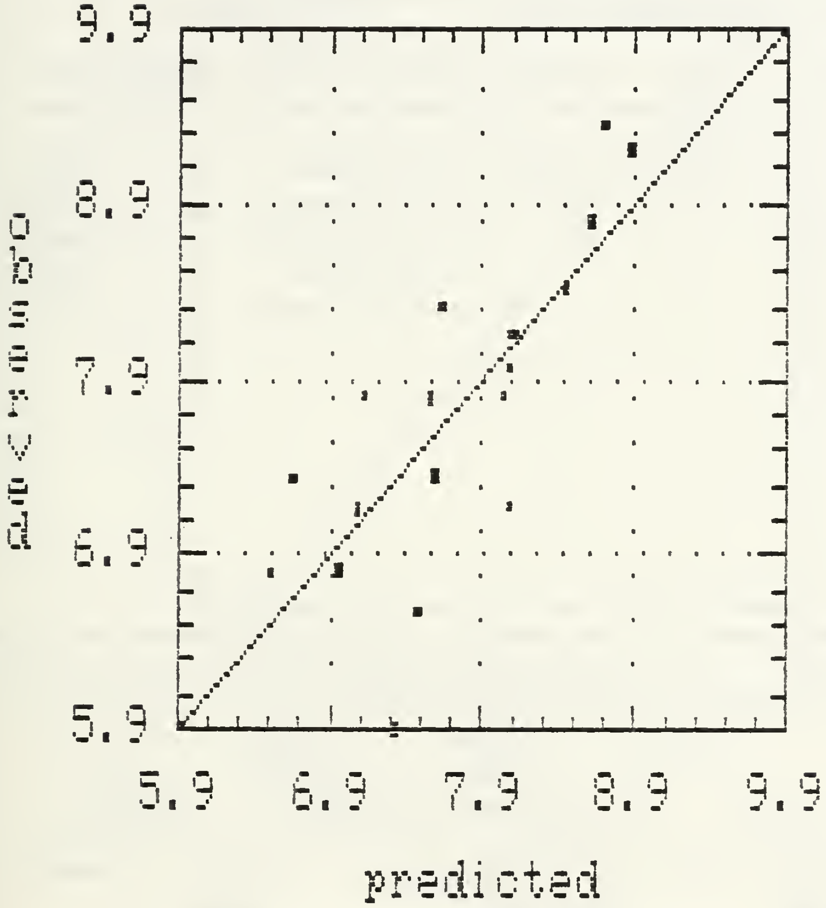

Frequency Histogram


Frequency Histogram
frequency
0
2
4
6
8
0
2
4
6
8
(X 10000)
WS

APPENDIX G: REGRESSION ANALYSIS

```
                   Model fitting results for: LOG totalhrs
==========================================================================
Independent variable          coefficient  std. error     t-value  sig.level
--------------------------------------------------------------------------
CONSTANT                        -1.644169    2.349697     -0.6997     0.4941
LOG vmaxa                        1.674174    0.368939      4.5378     0.0003
LOG weows                       -2.891408    1.030646     -2.8054     0.0127
--------------------------------------------------------------------------
R-SQ. (ADJ.) = 0.5399  SE=       0.607238  MAE=       0.414662  DurbWat=  2.397
Previously:    0.7060         1683.511947          963.114854             2.596
19 observations fitted, forecast(s) computed for 5 missing val. of dep. var.
```

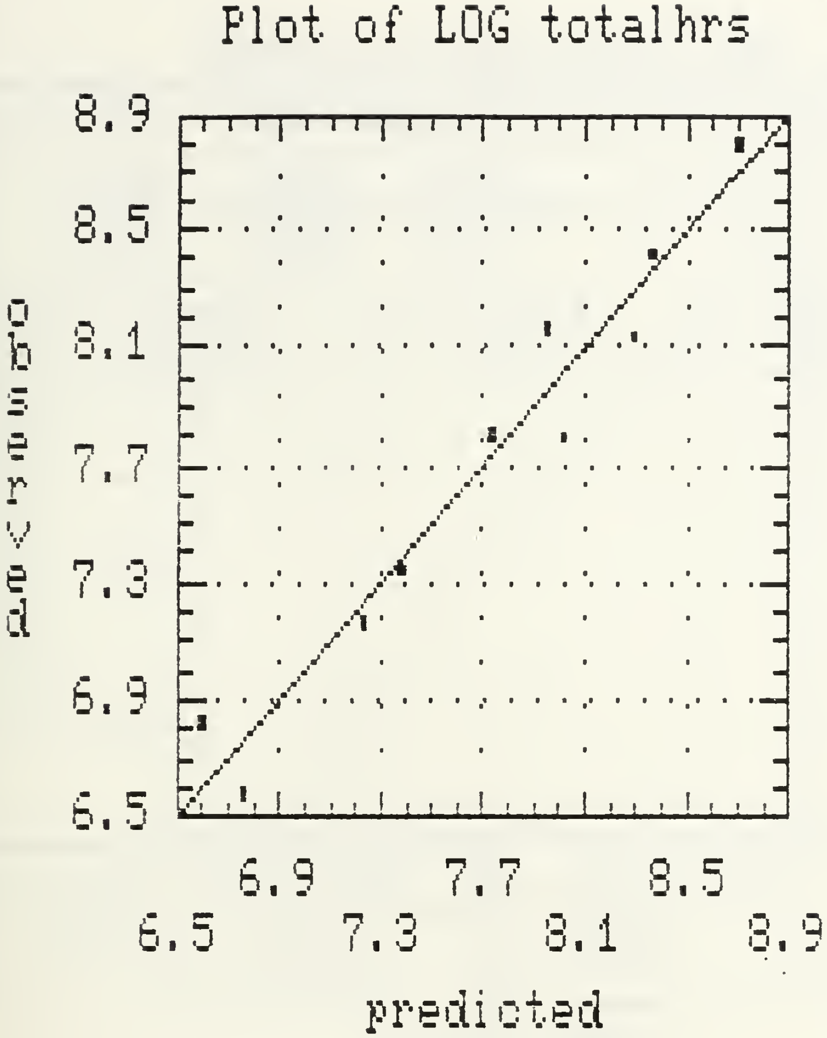
```
                   Analysis of Variance for the Full Regression
==========================================================================
Source                 Sum of Squares     DF    Mean Square     F-Ratio  P-value
--------------------------------------------------------------------------
Model                         8.52498      2        4.26249     11.5597    .0008
Error                         5.89981     16       0.368738
--------------------------------------------------------------------------
Total (Corr.)                 14.4248     18

R-squared = 0.590995                          Stnd. error of est. = 0.607238
R-squared (Adj. for d.f.) = 0.53987        Durbin-Watson statistic = 2.39708
```


Plot of LOG totalhrs

```
                      Stepwise Selection for LOG totalhrs
==============================================================================
Selection: Forward              Maximum steps: 500            F-to-enter: 4.00
Control: Manual                     Step: 2                 F-to-remove: 4.00

R-squared:  .95175     Adjusted: .93797        MSE: 0.0316714         d.f.: 7

Variables in Model         Coeff.  F-Remove  Variables Not in Model P.Corr. F-Enter
------------------------------------------------------------------------------
  1. LOG ws              0.98550   88.4172  2. LOG we              .0818     .0404
  7. LOG vmaxs           1.46814   34.1405  3. LOG weows           .0978     .0580
                                            4. LOG vmaxa           .1065     .0688
                                            5. LOG vcruise         .2166     .2954
                                            6. LOG gtow            .1600     .1577
                                            8. LOG gtowows         .1601     .1577
```

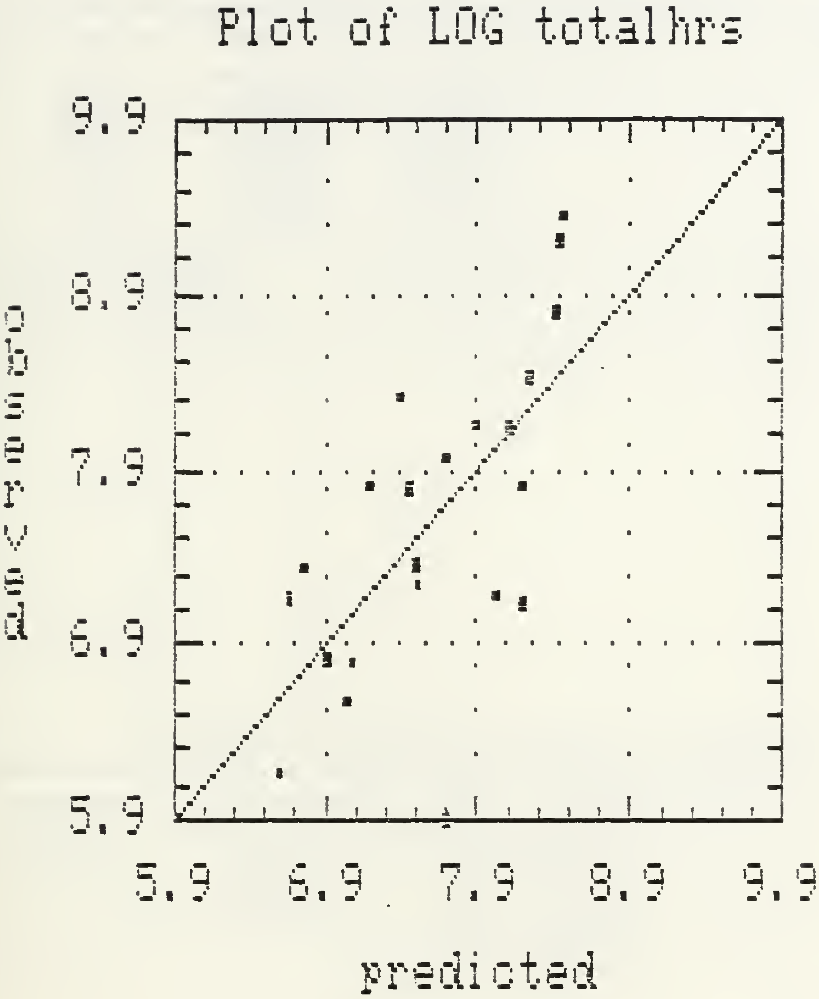
```
                     Model fitting results for: LOG totalhrs
------------------------------------------------------------------------------
Independent variable                coefficient  std. error      t-value   sig.level
------------------------------------------------------------------------------
CONSTANT                             -10.899863    1.781637      -6.1179      0.0005
LOG ws                                 0.985498    0.104806       9.4030      0.0000
LOG vmaxs                              1.468145    0.251266       5.8430      0.0006
------------------------------------------------------------------------------
R-SQ. (ADJ.) = 0.9380  SE=       0.177965  MAE=        0.132311  DurbWat=  2.029
Previously:    0.9380            0.177965              0.132311            2.029
10 observations fitted, forecast(s) computed for 3 missing val. of dep. var.
```

```
                     Analysis of Variance for the Full Regression
------------------------------------------------------------------------------
Source               Sum of Squares     DF     Mean Square       F-Ratio    P-value
------------------------------------------------------------------------------
Model                      4.37345       2         2.18672       69.0440      .0000
Error                     0.221700       7       0.0316714
------------------------------------------------------------------------------
Total (Corr.)              4.59515       9

R-squared = 0.951753                             Stnd. error of est. = 0.177965
R-squared (Adj. for d.f.) = 0.937969          Durbin-Watson statistic = 2.02894
```


Plot of LOG totalhrs

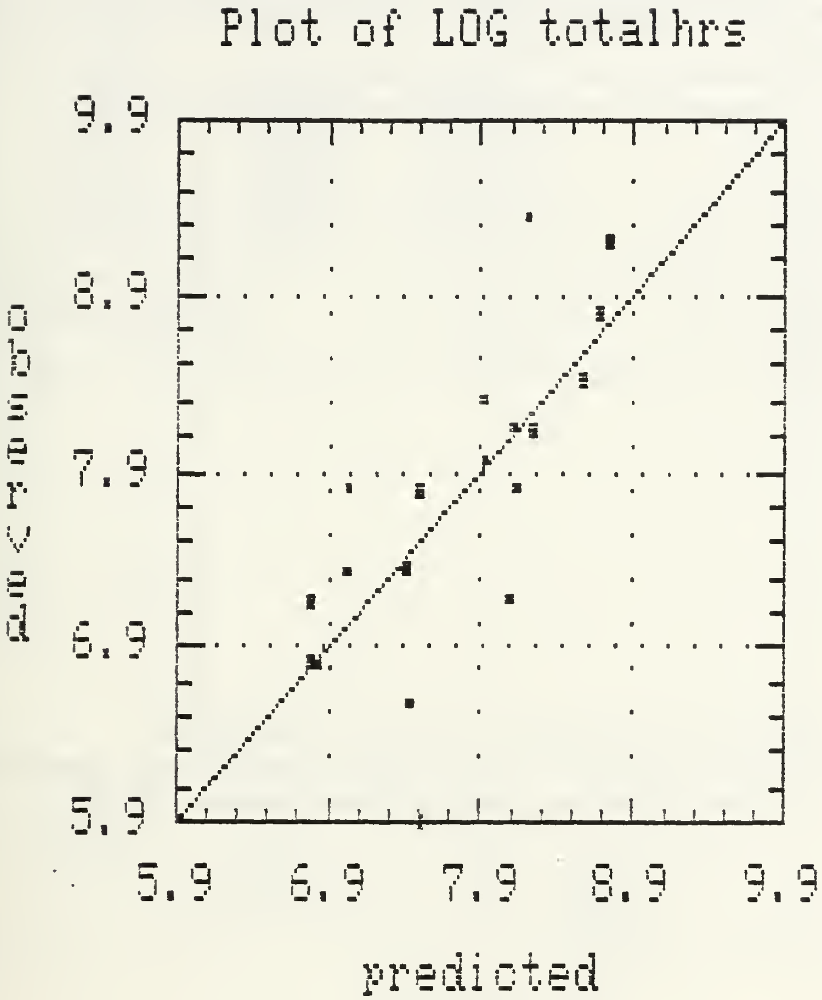
```
                    Model fitting results for: LOG totalhrs
==========================================================================
Independent variable               coefficient  std. error    t-value  sig.level
--------------------------------------------------------------------------
CONSTANT                              -4.78732    3.188752    -1.5013     0.1497
LOG gtow                              0.272277    0.142315     1.9132     0.0709
LOG vmaxa                             1.415453    0.385744     3.6694     0.0016
--------------------------------------------------------------------------
R-SQ. (ADJ.) = 0.3906  SE=       0.704933  MAE=       0.523254  DurbWat=  2.408
Previously:    0.0000            0.000000             0.000000            0.000
22 observations fitted, forecast(s) computed for 5 missing val. of dep. var.
```

```
                  Analysis of Variance for the Full Regression
==========================================================================
Source                 Sum of Squares     DF    Mean Square      F-Ratio   P-value
--------------------------------------------------------------------------
Model                         7.68378      2        3.84189      7.73125     .0035
Error                         9.44168     19       0.496931
--------------------------------------------------------------------------
Total (Corr.)                 17.1255     21

R-squared = 0.448676                          Stnd. error of est. = 0.704933
R-squared (Adj. for d.f.) = 0.390642     Durbin-Watson statistic = 2.40754
```


Plot of LOG totalhrs
9.9
8.9
7.9
6.9
5.9
observed
5.9
6.9
7.9
8.9
9.9
predicted

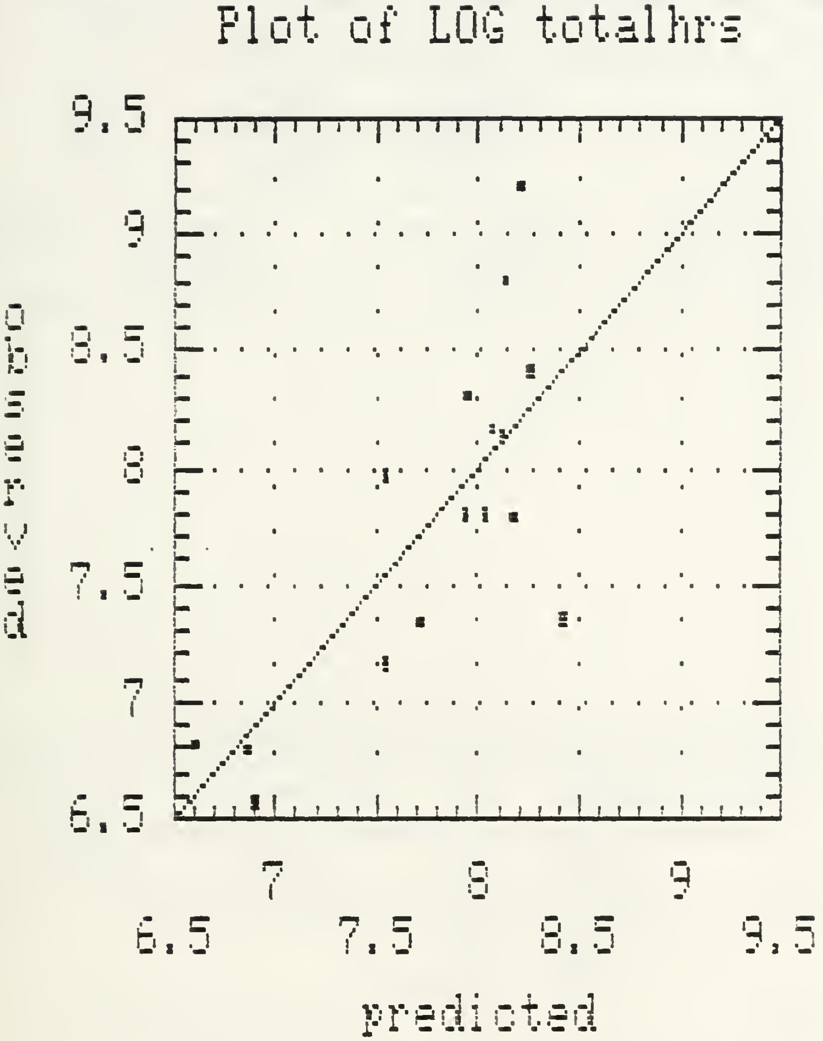
```
                     Model fitting results for: LOG totalhrs
================================================================================
Independent variable               coefficient  std. error     t-value   sig.level
--------------------------------------------------------------------------------
CONSTANT                             -4.002193    3.457228     -1.1576      0.2651
LOG ws                                0.942916    0.686458      1.3736      0.1897
LOG gtow                             -0.702926    0.687902     -1.0218      0.3231
LOG vmaxa                             1.562414    0.406271      3.8457      0.0016
--------------------------------------------------------------------------------
R-SQ. (ADJ.) = 0.4249  SE=        0.678881  MAE=        0.425286  DurbWat=  2.346
Previously:    0.0000             0.000000              0.000000            0.000
19 observations fitted, forecast(s) computed for 5 missing val. of dep. var.
```

```
                    Analysis of Variance for the Full Regression
================================================================================
Source                 Sum of Squares     DF    Mean Square      F-Ratio   P-value
--------------------------------------------------------------------------------
Model                         7.51159      3        2.50386      5.43279     .0099
Error                         6.91320     15       0.460880
--------------------------------------------------------------------------------
Total (Corr.)                 14.4248     18

R-squared = 0.520742                             Stnd. error of est. = 0.678881
R-squared (Adj. for d.f.) = 0.42489           Durbin-Watson statistic = 2.34636
```


Plot of LOG totalhrs
9.9
8.9
7.9
6.9
5.9
observed
5.9
6.9
7.9
8.9
9.9
predicted

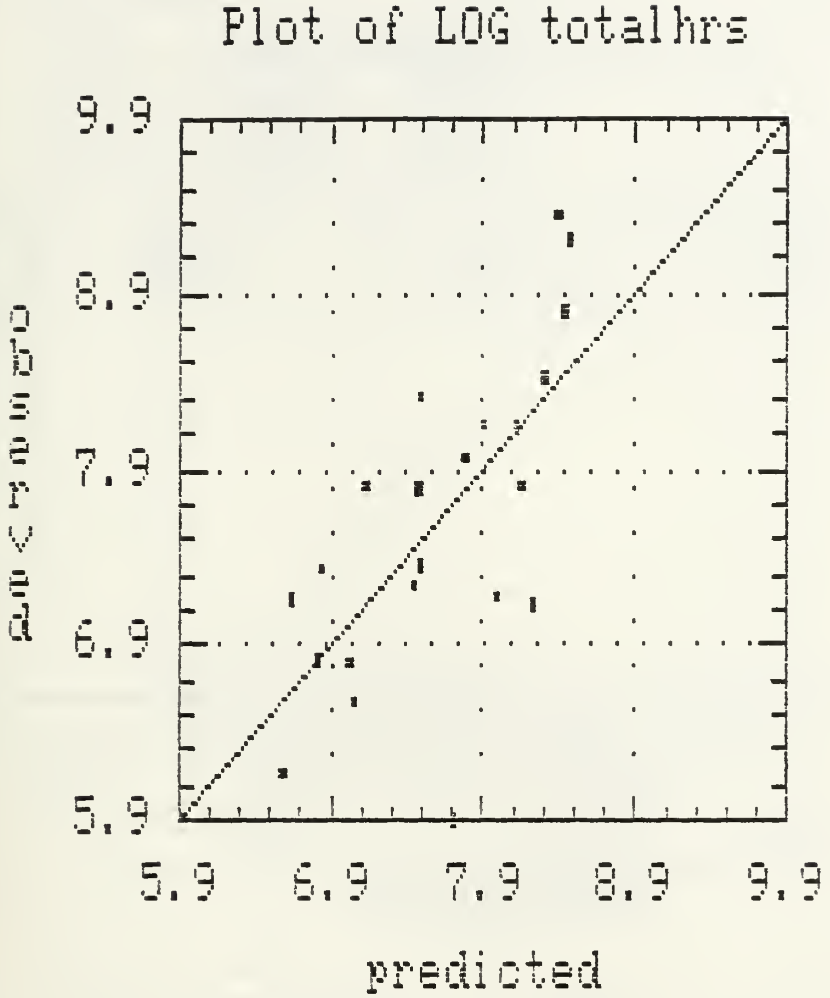
```
                    Model fitting results for: LOG totalhrs
================================================================================
Independent variable            coefficient  std. error     t-value   sig.level
--------------------------------------------------------------------------------
CONSTANT                         -84.270745   28.941247     -2.9118      0.0141
LOG ws                            -4.975196    2.265801     -2.1958      0.0505
LOG we                            63.286114   20.602163      3.0718      0.0106
LOG we DIVIDE LOG ws             -64.565417   21.422902     -3.0139      0.0118
LOG vcruise                        1.176559    0.947667      1.2415      0.2402
--------------------------------------------------------------------------------
R-SQ. (ADJ.) = 0.3979  SE=       0.571264  MAE=       0.368527  DurbWat=  1.101
Previously:    0.0000            0.000000             0.000000              0.000
16 observations fitted, forecast(s) computed for 4 missing val. of dep. var.
```

```
                  Analysis of Variance for the Full Regression
================================================================================
Source                  Sum of Squares     DF    Mean Square      F-Ratio  P-value
--------------------------------------------------------------------------------
Model                          4.54038      4        1.13509      3.47823    .0454
Error                          3.58976     11       0.326342
--------------------------------------------------------------------------------
Total (Corr.)                  8.13014     15

R-squared = 0.558462                              Stnd. error of est. = 0.571264
R-squared (Adj. for d.f.) = 0.397903           Durbin-Watson statistic = 1.10092
```


Plot of LOG totalhrs
9.5
9
8.5
8
7.5
7
6.5
observed
7
8
9
6.5
7.5
8.5
9.5
predicted

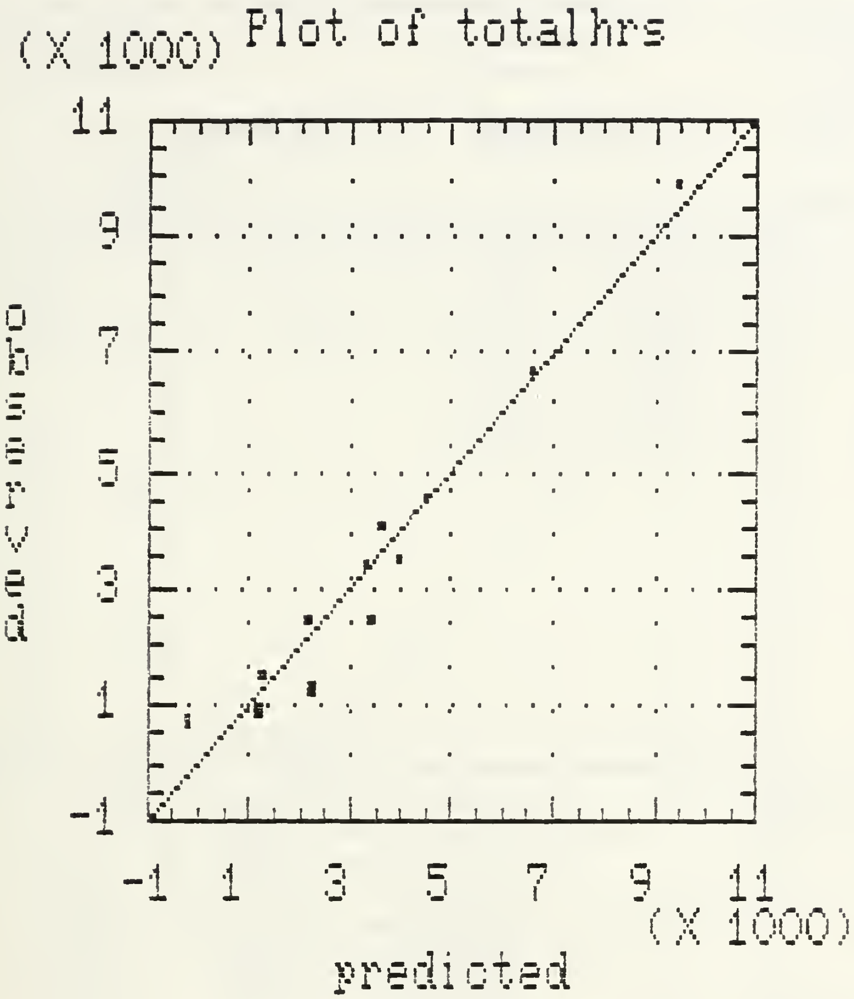
```
                    Model fitting results for: LOG totalhrs
==========================================================================
Independent variable            coefficient  std. error    t-value  sig.level
--------------------------------------------------------------------------
CONSTANT                          -5.024162    3.147581    -1.5962     0.1269
LOG we                             0.318161    0.154253     2.0626     0.0531
LOG vmaxa                          1.411488    0.380101     3.7135     0.0015
--------------------------------------------------------------------------
R-SQ. (ADJ.) = 0.4062  SE=       0.695872  MAE=       0.499345  DurbWat=  2.481
Previously:    0.0000            0.000000             0.000000            0.000
22 observations fitted, forecast(s) computed for 5 missing val. of dep. var.
```

```
                   Analysis of Variance for the Full Regression
==========================================================================
Source                 Sum of Squares     DF     Mean Square     F-Ratio   P-value
--------------------------------------------------------------------------
Model                         7.92494      2         3.96247     8.18290     .0027
Error                         9.20052     19        0.484238
--------------------------------------------------------------------------
Total (Corr.)                 17.1255     21

R-squared = 0.462758                            Stnd. error of est. = 0.695872
R-squared (Adj. for d.f.) = 0.406206         Durbin-Watson statistic = 2.48074
```


Plot of LOG totalhrs
observed
predicted
5.9
6.9
7.9
8.9
9.9
5.9
6.9
7.9
8.9
9.9

```
                         Model fitting results for: totalhrs
====================================================================================
Independent variable                   coefficient  std. error      t-value   sig.level
------------------------------------------------------------------------------------
CONSTANT                              -6726.836552 1012.435443      -6.6442      0.0003
vmaxa                                     2.330642    0.87699        2.6575      0.0326
wl                                       35.224491   10.321967       3.4126      0.0112
ws DIVIDE wavi                           97.288109   23.353698       4.1659      0.0042
we                                        0.132533    0.037022       3.5799      0.0090
------------------------------------------------------------------------------------
R-SQ. (ADJ.) = 0.9280  SE=      712.704726  MAE=      436.237562  DurbWat=  0.892
Previously:    0.0000            0.000000              0.000000             0.000
12 observations fitted, forecast(s) computed for 10 missing val. of dep. var.
```

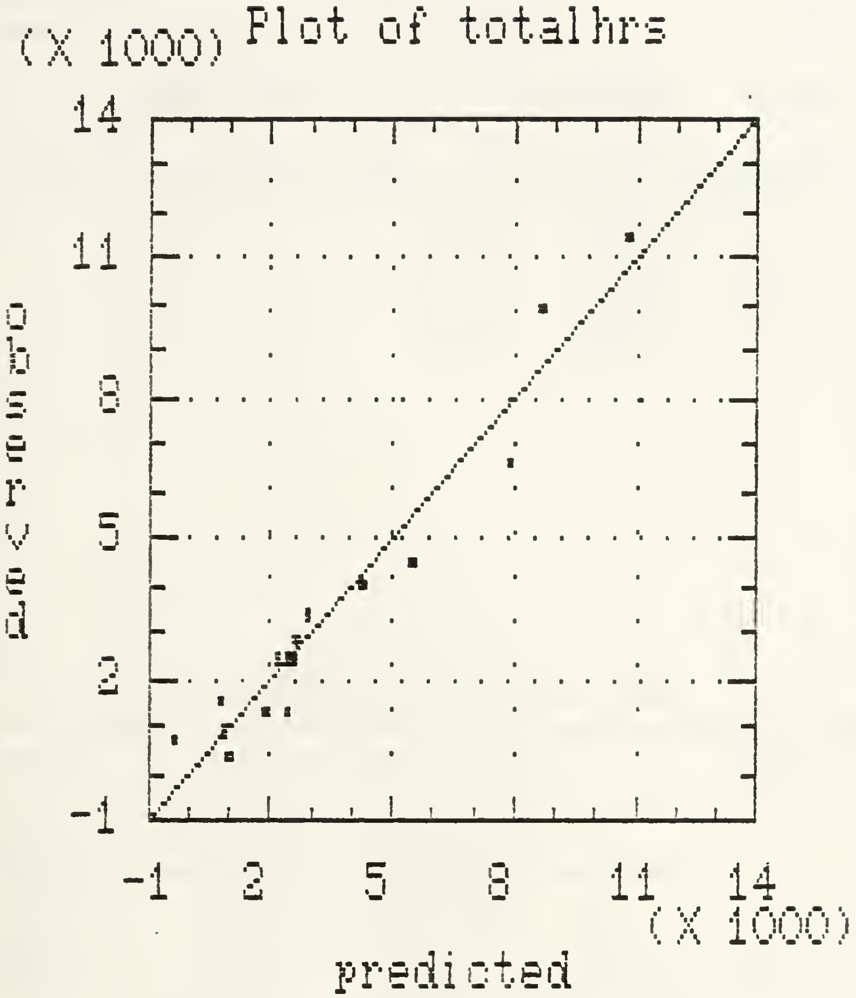
```
                      Analysis of Variance for the Full Regression
====================================================================================
Source                   Sum of Squares     DF     Mean Square        F-Ratio   P-value
------------------------------------------------------------------------------------
Model                         74004804.      4       18501201.        36.4234     .0001
Error                          3555636.      7         507948.
------------------------------------------------------------------------------------
Total (Corr.)                 77560440.     11

R-squared = 0.954157                                  Stnd. error of est. = 712.705
R-squared (Adj. for d.f.) = 0.92796              Durbin-Watson statistic = 0.892229
```


Plot of totalhrs
(X 1000)
observed
11
9
7
5
3
1
-1
-1
1
3
5
7
9
11
(X 1000)
predicted

```
                      Stepwise Selection for totalhrs
===========================================================================
Selection: Backward            Maximum steps: 500              F-to-enter: 4.00
Control: Manual                    Step: 3                    F-to-remove: 4.00

R-squared:  .94437     Adjusted: .90728          MSE: 973045            d.f.: 9

Variables in Model         Coeff.   F-Remove  Variables Not in Model  P.Corr.  F-Enter
---------------------------------------------------------------------------
  1. vmaxa                8.14256   83.3816  7. cq                      .2576     .5684
  2. ws DIVIDE wavi       194.380   20.6772  8. ff RAISE 3              .2691     .6243
  3. wavu                 2.33100   28.8253  9. serceil                 .0949     .0727
  4. gtow               -0.02500    42.1519
  5. weows              -13021.5    46.2526
  6. gtowows             909.081     8.3928
```

```
                      Model fitting results for: totalhrs
===========================================================================
Independent variable                 coefficient  std. error     t-value   sig.level
---------------------------------------------------------------------------
CONSTANT                            12749.531908 4000.619381      3.1869      0.0111
vmaxa                                   8.142559    0.891715      9.1314      0.0000
ws DIVIDE wavi                        194.379668   42.746922      4.5472      0.0014
wavu                                    2.331001    0.434166      5.3689      0.0005
gtow                                   -0.025003    0.003851     -6.4924      0.0001
weows                               -1.302149E4 1914.664197     -6.8009      0.0001
gtowows                               909.080784  313.797035      2.8970      0.0177
---------------------------------------------------------------------------
R-SQ. (ADJ.) = 0.9073   SE=      986.430249  MAE=       609.756674  DurbWat=  2.240
Previously:    0.6783          1760.963833             1067.911642            2.201
16 observations fitted, forecast(s) computed for 2 missing val. of dep. var.
```

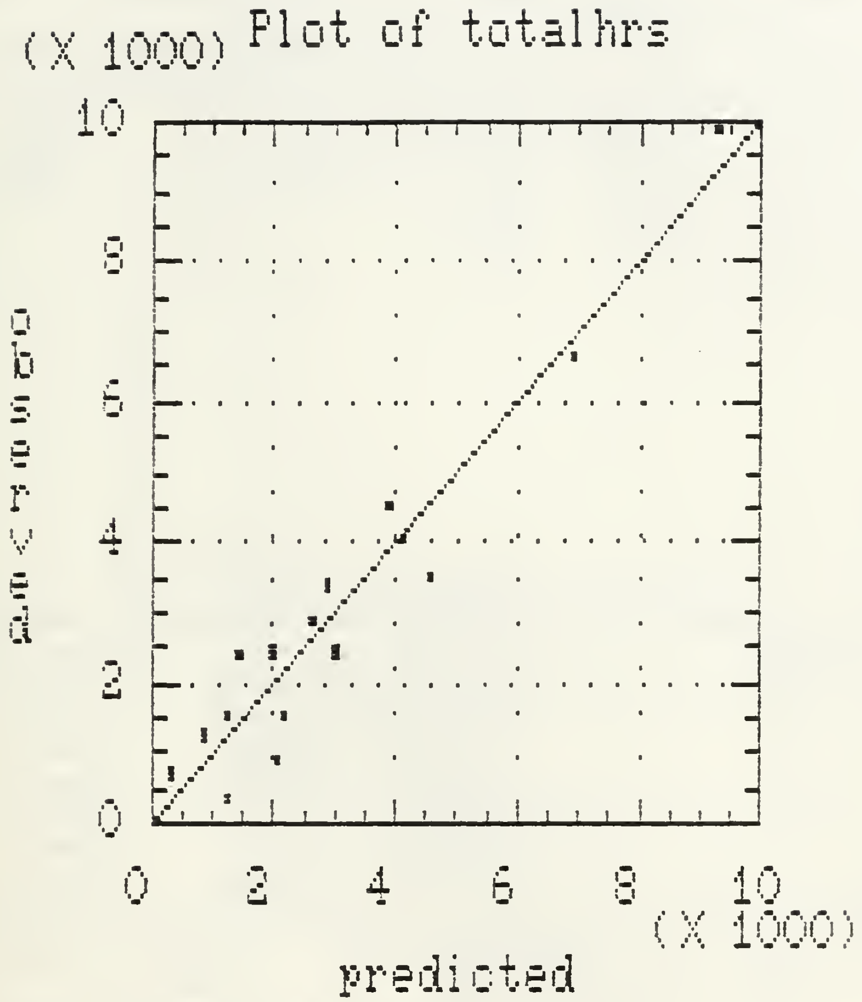
```
                 Analysis of Variance for the Full Regression
===========================================================================
Source                 Sum of Squares     DF      Mean Square       F-Ratio    P-value
---------------------------------------------------------------------------
Model                      148657177.      6        24776196.       25.4625      .0000
Error                        8757402.      9          973045.
---------------------------------------------------------------------------
Total (Corr.)              157414578.     15

R-squared = 0.944367                                  Stnd. error of est. = 986.43
R-squared (Adj. for d.f.) = 0.907279             Durbin-Watson statistic = 2.24001
```


(X 1000) Plot of totalhrs
observed
14
11
8
5
2
-1
-1
2
5
8
11
14
(X 1000)
predicted

```
                      Stepwise Selection for totalhrs
===========================================================================
Selection: Forward             Maximum steps: 500          F-to-enter: 4.00
Control: Manual                     Step: 2               F-to-remove: 4.00

R-squared:  .92416     Adjusted: .88625      MSE: 677250           d.f.: 10

Variables in Model       Coeff.  F-Remove  Variables Not in Model P.Corr. F-Enter
---------------------------------------------------------------------------

  1. vmaxa              4.96938   32.8124
  2. wl                 54.0451   31.5327
  3. ws DIVIDE wavi     156.815   19.1014
  4. gtow              -0.01428   16.8802
  5. wavi               0.87475    8.8128
```

```
                     Model fitting results for: totalhrs
---------------------------------------------------------------------------
Independent variable                coefficient  std. error     t-value   sig.level
---------------------------------------------------------------------------
CONSTANT                           -9300.697159 1377.000197     -6.7543      0.0001
vmaxa                                  4.969379    0.867528      5.7282      0.0002
wl                                    54.045094    9.624444      5.6154      0.0002
ws DIVIDE wavi                       156.815223   35.880272      4.3705      0.0014
gtow                                   -0.01428    0.003476     -4.1085      0.0021
wavi                                   0.874754    0.294665      2.9686      0.0141
---------------------------------------------------------------------------
R-SQ. (ADJ.) = 0.8862  SE=      822.951850  MAE=       577.829045  DurbWat=  2.369
Previously:     0.0000           0.000000             0.000000              0.000
16 observations fitted, forecast(s) computed for 8 missing val. of dep. var.
```

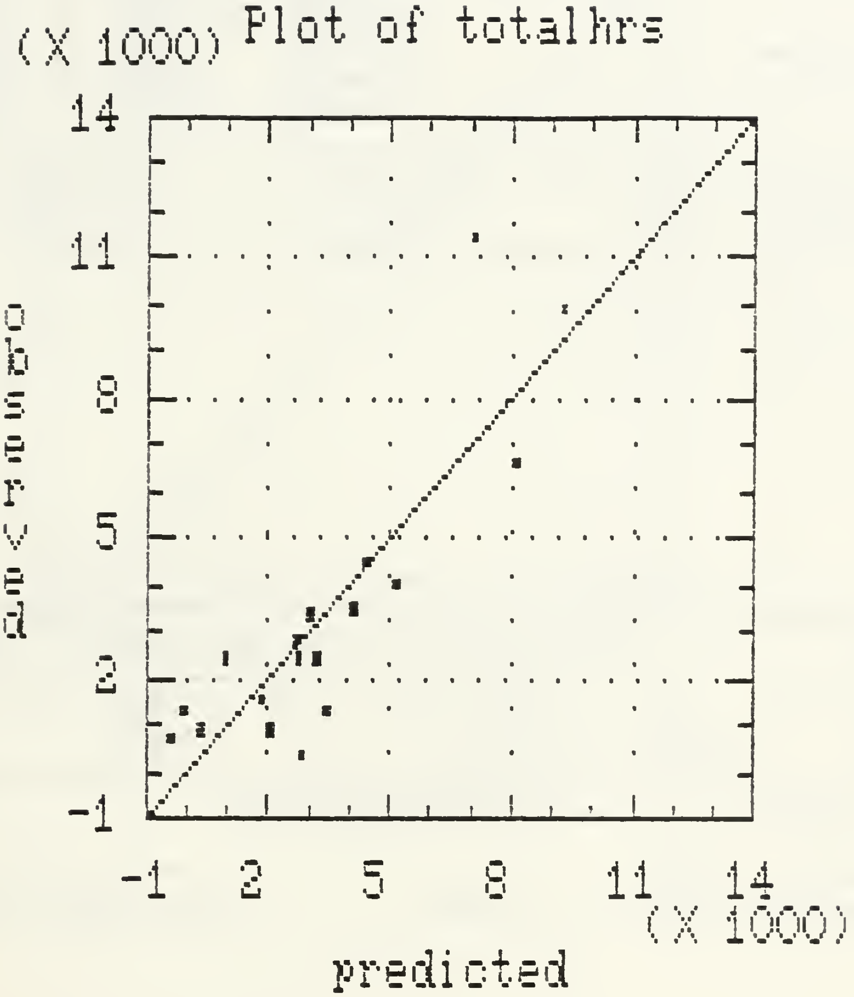
```
                   Analysis of Variance for the Full Regression
---------------------------------------------------------------------------
Source                 Sum of Squares     DF    Mean Square       F-Ratio   P-value
---------------------------------------------------------------------------
Model                       82532342.      5      16506468.       24.3728     .0000
Error                        6772497.     10        677250.
---------------------------------------------------------------------------
Total (Corr.)               89304839.     15

R-squared = 0.924164                                  Stnd. error of est. = 822.952
R-squared (Adj. for d.f.) = 0.886246              Durbin-Watson statistic = 2.3691
```


Plot of totalhrs
(X 1000)
observed
0
2
4
6
8
10
predicted
0
2
4
6
8
10
(X 1000)

```
                    Stepwise Selection for totalhrs
============================================================================
Selection: Backward           Maximum steps: 500          F-to-enter: 4.00
Control: Manual                    Step: 3               F-to-remove: 4.00

R-squared:  .74445     Adjusted: .63797        MSE: 3.49019E6       d.f.: 12

Variables in Model        Coeff.  F-Remove  Variables Not in Model P.Corr. F-Enter
----------------------------------------------------------------------------------
  1. vmaxa               6.67724   15.9442  5. ff                    .0811   .0728
  2. wl                  46.0690    4.9906  6. gtow                  .1020   .1156
  3. wavu                2.29306   10.5702  7. we DIVIDE wavi        .3706  1.7509
  4. we                 -0.04799    7.8223
  8. ws DIVIDE wavi      234.509    9.5858
```

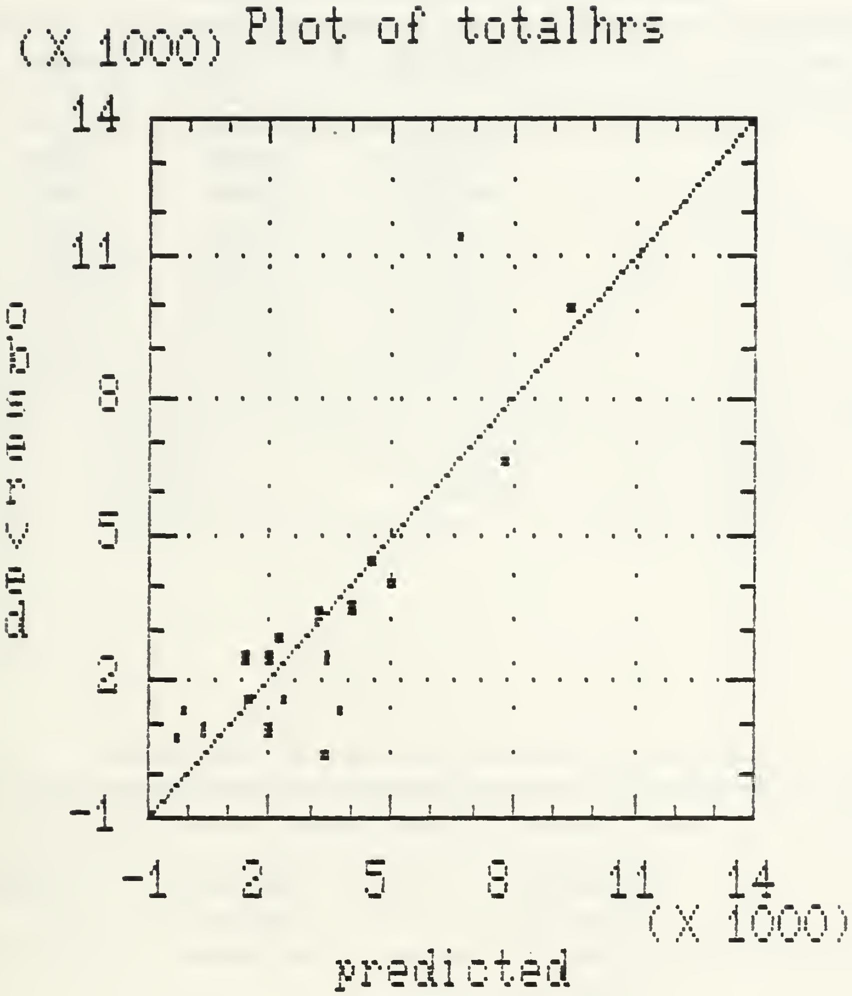
```
                      Model fitting results for: totalhrs
============================================================================
Independent variable                 coefficient  std. error    t-value   sig.level
----------------------------------------------------------------------------
CONSTANT                            -1.191286E4 3036.321909    -3.9235     0.0020
vmaxa                                  6.677243    1.672231     3.9930     0.0018
wl                                    46.069036   20.622155     2.2340     0.0453
wavu                                   2.293064      0.7053     3.2512     0.0069
we                                    -0.047986    0.017157    -2.7968     0.0161
ws DIVIDE wavi                       234.508931    75.74366     3.0961     0.0093
----------------------------------------------------------------------------
R-SQ. (ADJ.) = 0.6380  SE=     1868.205589  MAE=      1131.250970  DurbWat=  2.332
Previously:     0.0000           0.000000            0.000000            0.000
18 observations fitted, forecast(s) computed for 4 missing val. of dep. var.
```

```
                 Analysis of Variance for the Full Regression
============================================================================
Source                 Sum of Squares     DF     Mean Square      F-Ratio   P-value
----------------------------------------------------------------------------
Model                      122010310.      5       24402062.      6.99161     .0028
Error                       41882305.     12        3490192.
----------------------------------------------------------------------------
Total (Corr.)              163892615.     17

R-squared = 0.744453                              Stnd. error of est. = 1868.21
R-squared (Adj. for d.f.) = 0.637975          Durbin-Watson statistic = 2.33243
```


Plot of totalhrs
(X 1000)
14
11
8
5
2
-1
observed
-1
2
5
8
11
14
(X 1000)
predicted

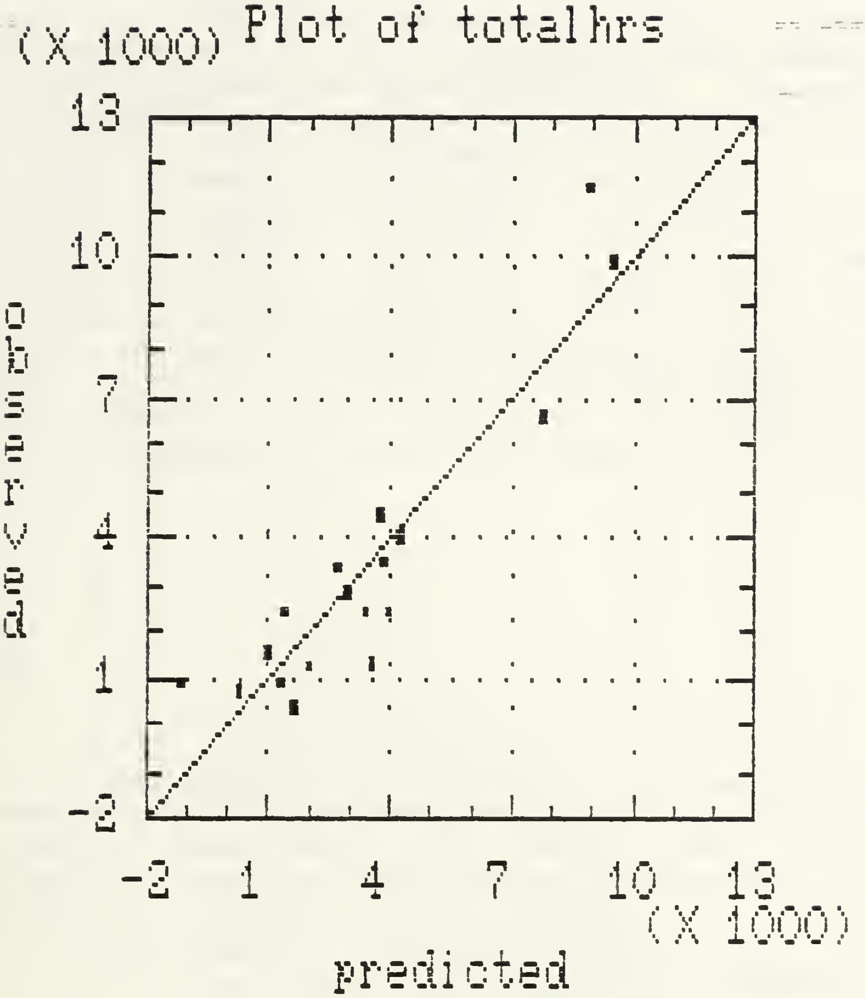
```
                          Model fitting results for: totalhrs
==========================================================================================
Independent variable                 coefficient  std. error        t-value    sig.level
------------------------------------------------------------------------------------------
CONSTANT                          -1.147354E4 3148.144654        -3.6445       0.0030
vmaxa                                7.064267     1.70583          4.1412       0.0012
wl                                  42.037725   20.760173          2.0249       0.0639
ws DIVIDE wavi                     219.724726   78.772184          2.7894       0.0153
we                                  -0.048325    0.018965         -2.5482       0.0243
wavi                                 1.600989    0.552012          2.9003       0.0124
------------------------------------------------------------------------------------------
R-SQ. (ADJ.) = 0.6008  SE=    1924.645484  MAE=     1128.024872  DurbWat=  2.794
Previously:    0.0000            0.000000             0.000000              0.000
19 observations fitted, forecast(s) computed for 5 missing val. of dep. var.
```

```
                      Analysis of Variance for the Full Regression
==========================================================================================
Source                 Sum of Squares      DF     Mean Square        F-Ratio   P-value
------------------------------------------------------------------------------------------
Model                      118866336.       5       23773267.        6.41782     .0033
Error                       48155383.      13        3704260.
------------------------------------------------------------------------------------------
Total (Corr.)              167021719.      18

R-squared = 0.711682                              Stnd. error of est. = 1924.65
R-squared (Adj. for d.f.) = 0.60079            Durbin-Watson statistic = 2.79406
```

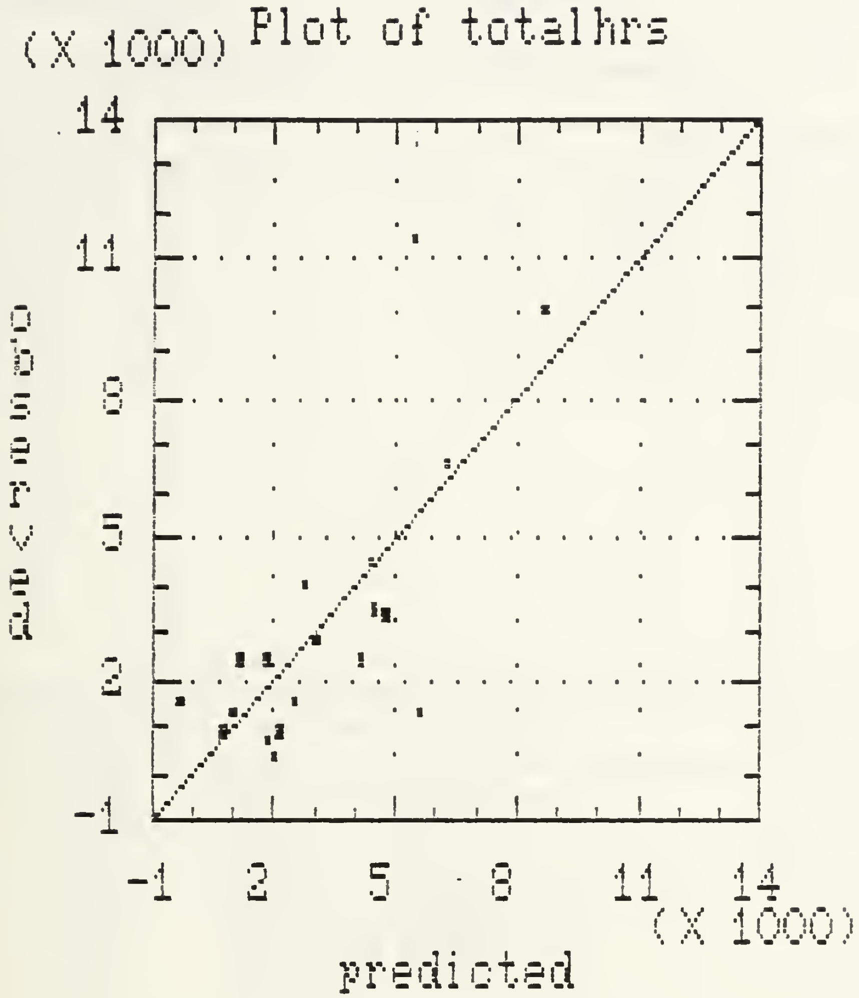

Plot of totalhrs
(X 1000)
14
11
8
5
2
-1
observed
-1
2
5
8
11
14
(X 1000)
predicted

```
                     Model fitting results for: totalhrs
================================================================================
Independent variable            coefficient  std. error      t-value   sig.level
--------------------------------------------------------------------------------
CONSTANT                        -1.077698E4 3383.833165      -3.1848      0.0111
vmaxa                              7.539102    1.781093       4.2329      0.0022
wl                                 46.55265   20.553606       2.2649      0.0498
wavu                               2.576484    0.800791       3.2174      0.0105
we DIVIDE wavi                  -407.440752  172.078252      -2.3678      0.0421
we                                -0.243616    0.108182      -2.2519      0.0508
ff                               -29.563053   72.889472      -0.4056      0.6945
gtow                               0.060143    0.036311       1.6563      0.1320
ws DIVIDE wavi                   992.657877  332.312353       2.9826      0.0154
--------------------------------------------------------------------------------
R-SQ. (ADJ.) = 0.7060  SE=    1683.511947  MAE=      963.114854  DurbWat=  2.596
Previously:    0.0000            0.000000            0.000000              0.000
18 observations fitted, forecast(s) computed for 4 missing val. of dep. var.
```

```
                  Analysis of Variance for the Full Regression
================================================================================
Source                 Sum of Squares     DF    Mean Square      F-Ratio   P-value
--------------------------------------------------------------------------------
Model                      138384703.      8      17298088.      6.10331     .0069
Error                       25507912.      9       2834212.
--------------------------------------------------------------------------------
Total (Corr.)              163892615.     17

R-squared = 0.844362                               Stnd. error of est. = 1683.51
R-squared (Adj. for d.f.) = 0.706017           Durbin-Watson statistic = 2.59577
```


Plot of totalhrs
(X 1000)
13
10
7
4
1
-2
observed
-2
1
4
7
10
13
(X 1000)
predicted

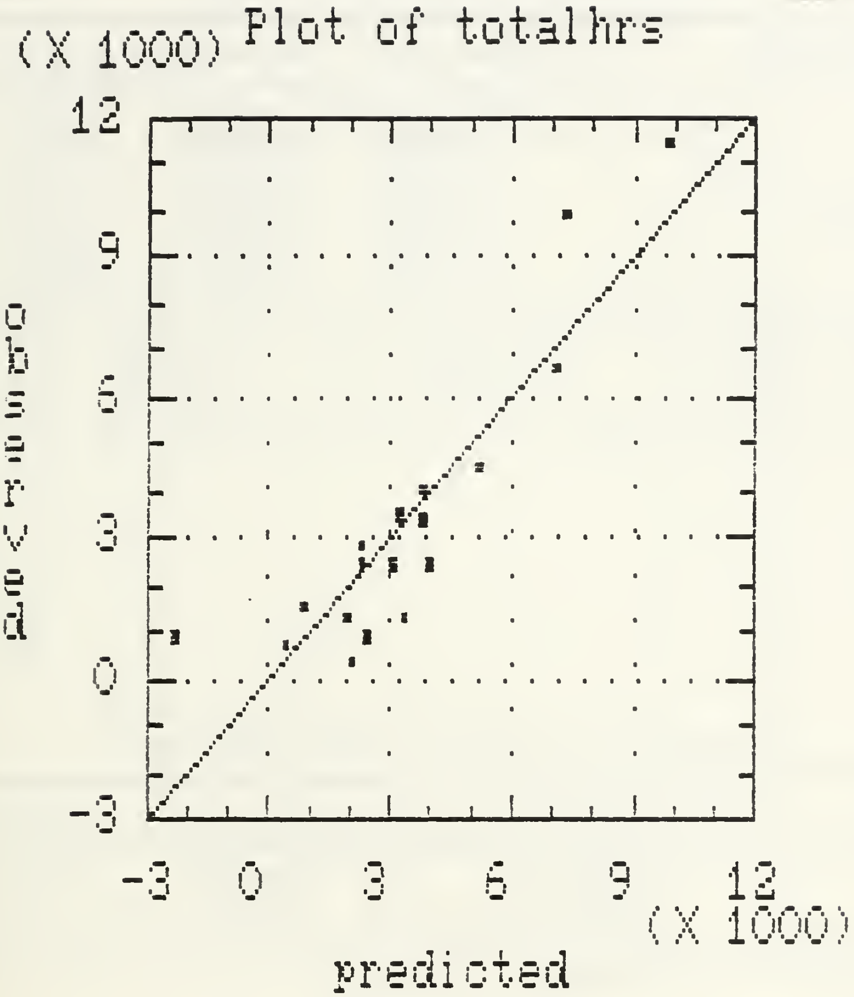
```
                    Model fitting results for: totalhrs
==============================================================================
Independent variable               coefficient  std. error      t-value   sig.level
------------------------------------------------------------------------------
CONSTANT                            -4966.2844 3144.648299      -1.5793      0.1383
vmaxa                                 6.003015      2.1484       2.7942      0.0152
wl                                   32.998473   25.591643       1.2894      0.2197
ws DIVIDE wavi                       23.604575   56.384542       0.4186      0.6823
gtow                                 -0.000798     0.00478      -0.1670      0.8699
cq                                 -965.452538 1271.433844      -0.7593      0.4612
------------------------------------------------------------------------------
R-SQ. (ADJ.) = 0.3701  SE=    2417.689738  MAE=     1407.425309  DurbWat=  2.073
Previously:    0.0000             0.000000            0.000000             0.000
19 observations fitted, forecast(s) computed for 5 missing val. of dep. var.




                  Analysis of Variance for the Full Regression
==============================================================================
Source               Sum of Squares     DF     Mean Square       F-Ratio   P-value
------------------------------------------------------------------------------
Model                     91033811.      5       18206762.       3.11481     .0458
Error                     75987908.     13        5845224.
------------------------------------------------------------------------------
Total (Corr.)            167021719.     18

R-squared = 0.545042                              Stnd. error of est. = 2417.69
R-squared (Adj. for d.f.) = 0.370058           Durbin-Watson statistic = 2.07341
```


Plot of totalhrs
(X 1000)
14
11
8
5
2
-1
observed
-1
2
5
8
11
14
(X 1000)
predicted

```
                      Stepwise Selection for totalhrs
=============================================================================
Selection: Backward          Maximum steps: 500            F-to-enter: 4.00
Control: Manual                  Step: 1                  F-to-remove: 4.00

R-squared:  .79187     Adjusted: .67834       MSE: 3.10099E6        d.f.: 11

Variables in Model      Coeff.  F-Remove  Variables Not in Model P.Corr. F-Enter
-----------------------------------------------------------------------------
  1. vmaxa             6.99089   20.6238  7. cq                    .0658    .0435
  2. ws DIVIDE wavi    145.229    4.0321
  3. wavu              1.61572    5.0800
  4. gtow             -0.01673    7.3714
  5. weows            -7687.24    7.2815
  6. gtowows           1108.63    4.0873
```

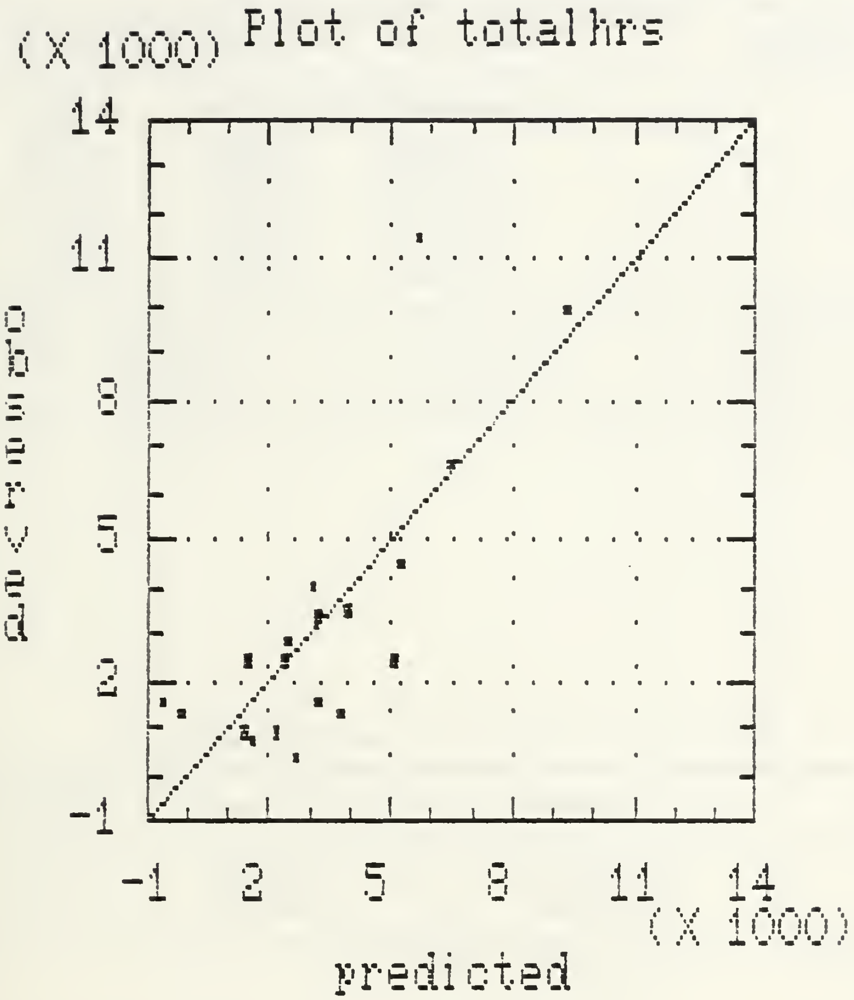
```
                      Model fitting results for: totalhrs
-----------------------------------------------------------------------------
Independent variable              coefficient  std. error     t-value   sig.level
-----------------------------------------------------------------------------
CONSTANT                          4414.960281 6371.611386      0.6929      0.5027
vmaxa                                6.990887    1.539388      4.5413      0.0008
ws DIVIDE wavi                     145.229295   72.324928      2.0080      0.0698
wavu                                 1.615719    0.716861      2.2539      0.0456
gtow                                -0.016729    0.006162     -2.7150      0.0201
weows                            -7687.240688 2848.782698     -2.6984      0.0207
gtowows                           1108.633655  548.367505      2.0217      0.0682
-----------------------------------------------------------------------------
R-SQ. (ADJ.) = 0.6783  SE=    1760.963833  MAE=    1067.911642  DurbWat=  2.201
Previously:    0.9073          986.430249            609.756674             2.240
18 observations fitted, forecast(s) computed for 4 missing val. of dep. var.
```

```
                Analysis of Variance for the Full Regression
-----------------------------------------------------------------------------
Source              Sum of Squares     DF     Mean Square      F-Ratio   P-value
-----------------------------------------------------------------------------
Model                   129781685.      6       21630281.      6.97527     .0030
Error                    34110930.     11        3100994.
-----------------------------------------------------------------------------
Total (Corr.)           163892615.     17

R-squared = 0.79187                          Stnd. error of est. = 1760.96
R-squared (Adj. for d.f.) = 0.678345         Durbin-Watson statistic = 2.20112
```

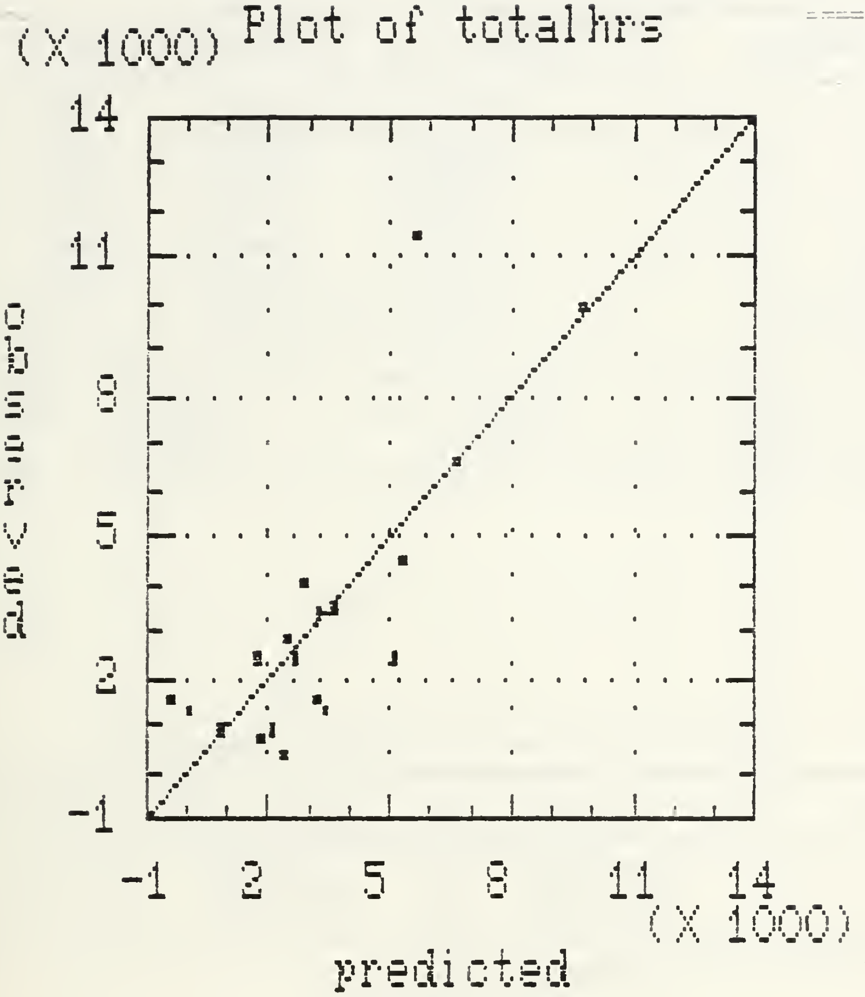

(X 1000)
Plot of totalhrs
12
9
6
3
0
-3
observed
-3
0
3
6
9
12
(X 1000)
predicted

```
                      Model fitting results for: totalhrs
================================================================================
Independent variable             coefficient  std. error     t-value   sig.level
--------------------------------------------------------------------------------
CONSTANT                        -5385.623196 2834.875627     -1.8998      0.0799
vmaxa                               5.653046    2.029718      2.7851      0.0155
wl                                 49.042364   26.462688      1.8533      0.0867
ws DIVIDE wavi                     28.888184   51.854799      0.5571      0.5869
gtow                                -0.00159      0.0045     -0.3532      0.7296
ff                               -104.436616   66.999514     -1.5588      0.1431
--------------------------------------------------------------------------------
R-SQ. (ADJ.) = 0.4457  SE=    2267.861733  MAE=    1349.153035  DurbWat=  2.503
Previously:    0.0000            0.000000             0.000000             0.000
19 observations fitted, forecast(s) computed for 5 missing val. of dep. var.
```

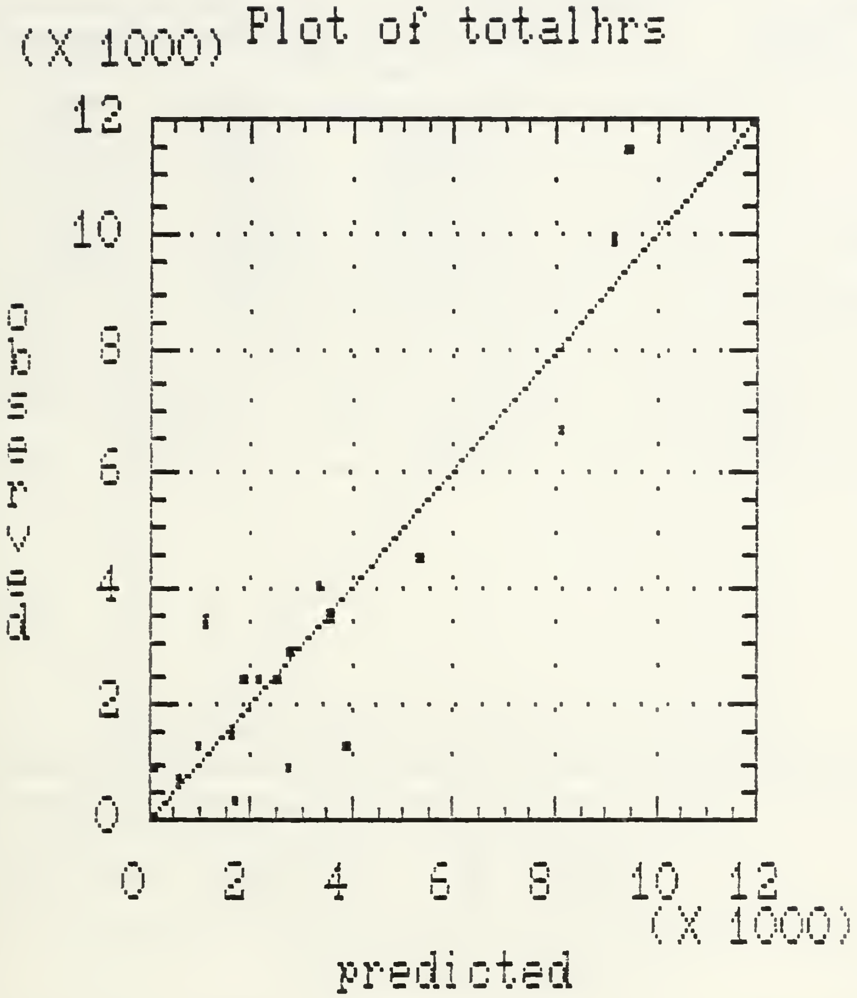
```
                  Analysis of Variance for the Full Regression
================================================================================
Source               Sum of Squares     DF    Mean Square      F-Ratio   P-value
--------------------------------------------------------------------------------
Model                    100160160.      5      20032032.      3.89486     .0223
Error                     66861559.     13       5143197.
--------------------------------------------------------------------------------
Total (Corr.)            167021719.     18

R-squared = 0.599683                               Stnd. error of est. = 2267.86
R-squared (Adj. for d.f.) = 0.445716           Durbin-Watson statistic = 2.50286
```


Plot of totalhrs
(X 1000)
14
11
8
5
2
-1
observed
-1
2
5
8
11
14
(X 1000)
predicted

```
                        Model fitting results for: totalhrs
==============================================================================
Independent variable           coefficient  std. error    t-value  sig.level
------------------------------------------------------------------------------
CONSTANT                      -5741.815982 2748.137258    -2.0893     0.0569
vmaxa                             5.458323    1.982469     2.7533     0.0164
wl                               50.908485   25.537522     1.9935     0.0676
ws DIVIDE wavi                   29.270494   50.323741     0.5816     0.5708
gtow                             -0.002188    0.004418    -0.4951     0.6288
ff RAISE 2                       -3.894643    2.120978    -1.8362     0.0893
------------------------------------------------------------------------------
R-SQ. (ADJ.) = 0.4776  SE=    2201.647296  MAE=    1240.300951  DurbWat=  2.549
Previously:    0.0000           0.000000            0.000000            0.000
19 observations fitted, forecast(s) computed for 5 missing val. of dep. var.




                    Analysis of Variance for the Full Regression
==============================================================================
Source                 Sum of Squares     DF    Mean Square     F-Ratio  P-value
------------------------------------------------------------------------------
Model                      104007459.      5      20801492.     4.29140    .0159
Error                       63014261.     13       4847251.
------------------------------------------------------------------------------
Total (Corr.)              167021719.     18

R-squared = 0.622718                             Stnd. error of est. = 2201.65
R-squared (Adj. for d.f.) = 0.47761         Durbin-Watson statistic = 2.5485
```

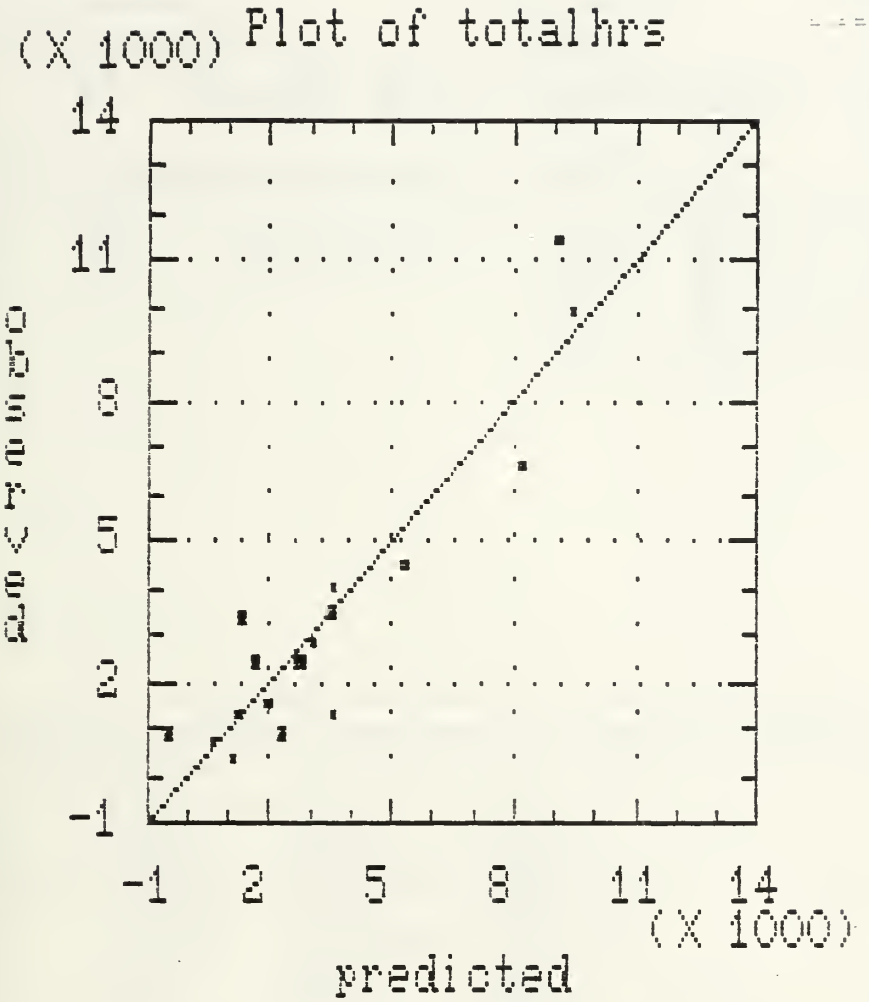

Plot of totalhrs
(X 1000)
14
11
8
5
2
-1
observed
-1
2
5
8
11
14
(X 1000)
predicted

```
                       Model fitting results for: totalhrs
==============================================================================
Independent variable                   coefficient  std. error    t-value  sig.level
------------------------------------------------------------------------------
CONSTANT                              -1.008728E4 3137.053076    -3.2155     0.0092
vmaxa                                    9.338453    1.839435     5.0768     0.0005
wl                                      28.362929   20.576164     1.3784     0.1981
wavu                                     1.895789     0.70721     2.6807     0.0231
we DIVIDE wavi                         150.108292   46.354616     3.2383     0.0089
we                                      -0.040676    0.013158    -3.0914     0.0114
thrust DIVIDE gtow                    -1.094131E4 3508.578638    -3.1184     0.0109
ff                                     190.285517   94.305322     2.0178     0.0712
------------------------------------------------------------------------------
R-SQ. (ADJ.) = 0.7291  SE=    1616.030773  MAE=      902.049649  DurbWat=  2.861
Previously:    0.0000          0.000000            0.000000              0.000
18 observations fitted, forecast(s) computed for 4 missing val. of dep. var.



                    Analysis of Variance for the Full Regression
==============================================================================
Source              Sum of Squares     DF     Mean Square       F-Ratio   P-value
------------------------------------------------------------------------------
Model                   137777061.      7       19682437.       7.53667     .0025
Error                    26115555.     10        2611555.
------------------------------------------------------------------------------
Total (Corr.)           163892615.     17

R-squared = 0.840654                            Stnd. error of est. = 1616.03
R-squared (Adj. for d.f.) = 0.729113      Durbin-Watson statistic = 2.861
```


Plot of totalhrs
(X 1000)
12
10
8
6
4
2
0
observed
0
2
4
6
8
10
12
(X 1000)
predicted

```
                          Model fitting results for: totalhrs
=======================================================================================
Independent variable                  coefficient  std. error      t-value   sig.level
---------------------------------------------------------------------------------------
CONSTANT                               -9813.6704 2863.161766      -3.4276      0.0065
vmaxa                                    8.694981     1.66529       5.2213      0.0004
wl                                      33.215811   19.614328       1.6934      0.1212
wavu                                     2.121268    0.709265       2.9908      0.0136
ws DIVIDE wavi                         260.320297   73.636122       3.5352      0.0054
we                                      -0.055863    0.016039      -3.4830      0.0059
thrust DIVIDE gtow                   -8589.128032 3137.092016      -2.7379      0.0209
ff                                     126.039147   78.127578       1.6132      0.1378
---------------------------------------------------------------------------------------
R-SQ. (ADJ.) = 0.7533  SE=    1542.096194  MAE=      867.476921  DurbWat=  2.692
Previously:    0.0000            0.000000              0.000000               0.000
18 observations fitted, forecast(s) computed for 4 missing val. of dep. var.
```

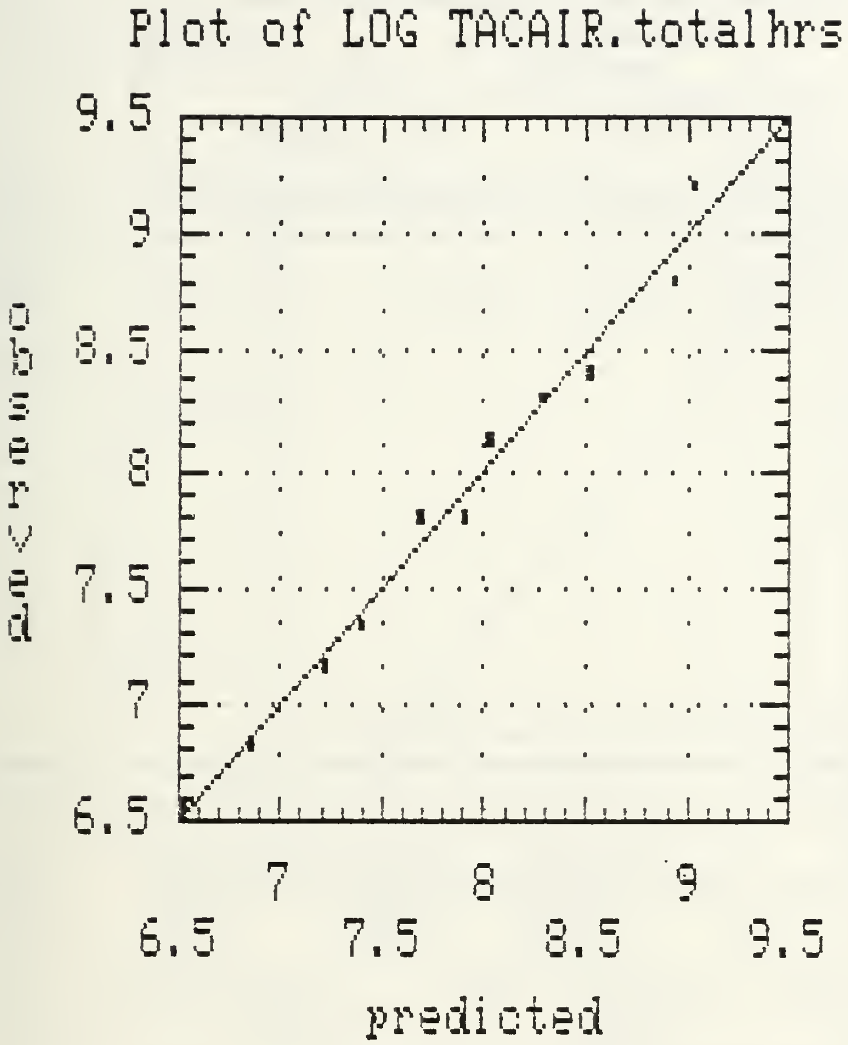
```
                    Analysis of Variance for the Full Regression
=======================================================================================
Source                   Sum of Squares     DF     Mean Square        F-Ratio   P-value
---------------------------------------------------------------------------------------
Model                        140112009.      7       20016001.        8.41694     .0016
Error                         23780607.     10        2378061.                        .
---------------------------------------------------------------------------------------
Total (Corr.)                163892615.     17

R-squared = 0.854901                                  Stnd. error of est. = 1542.1
R-squared (Adj. for d.f.) = 0.753332               Durbin-Watson statistic = 2.69151
```


Plot of totalhrs
(X 1000)
14
11
8
5
2
-1
observed
-1
2
5
8
11
14
(X 1000)
predicted

```
                     Stepwise Selection for LOG TACAIR.totalhrs
========================================================================
Selection: Backward          Maximum steps: 500           F-to-enter: 4.00
Control: Manual                   Step: 2                F-to-remove: 4.00

R-squared:  .98415     Adjusted: .96830          MSE: 0.0214077        d.f.: 5

Variables in Model        Coeff.  F-Remove  Variables Not in Model P.Corr. F-Enter
------------------------------------------------------------------------
  1. LOG TACAIR.vmax    0.69923   31.3357  5. LOG TACAIR.weow      .3518     .5649
  2. LOG TACAIR.ws/L    18.7550   25.2687  7. LOG TACAIR.serc      .1047     .0443
  3. LOG TACAIR.wavu    2.42565   21.5854
  4. LOG TACAIR.gtow  -17.0349    22.1357
  6. LOG TACAIR.gtow   17.1285    21.5176
```

```
                   Model fitting results for: LOG TACAIR.totalhrs
========================================================================
Independent variable              coefficient  std. error     t-value   sig.level
------------------------------------------------------------------------
CONSTANT                             6.874211     2.94801      2.3318      0.0671
LOG TACAIR.vmaxa                     0.699229    0.124911      5.5978      0.0025
LOG TACAIR.ws/LOG wavi              18.754967    3.730998      5.0268      0.0040
LOG TACAIR.wavu                      2.425654    0.522095      4.6460      0.0056
LOG TACAIR.gtow                    -17.03489     3.620704     -4.7049      0.0053
LOG TACAIR.gtowows                  17.128471    3.692506      4.6387      0.0056
------------------------------------------------------------------------
R-SQ. (ADJ.) = 0.9683  SE=        0.146314  MAE=        0.087641  DurbWat=  2.870
Previously:    0.0000             0.000000              0.000000            0.000
11 observations fitted, forecast(s) computed for 5 missing val. of dep. var.
```

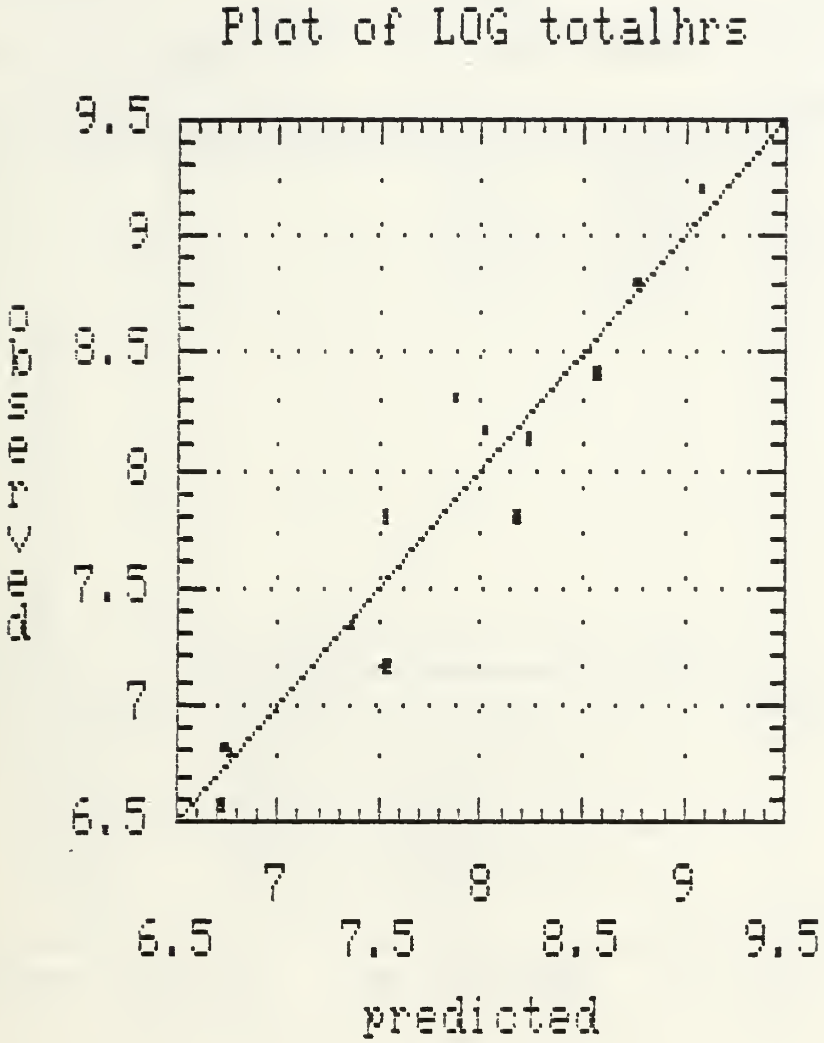
```
                 Analysis of Variance for the Full Regression
========================================================================
Source                  Sum of Squares     DF     Mean Square       F-Ratio    P-value
------------------------------------------------------------------------
Model                          6.64717      5         1.32943       62.1007      .0002
Error                         0.107039      5       0.0214077
------------------------------------------------------------------------
Total (Corr.)                  6.75421     10

R-squared = 0.984152                             Stnd. error of est. = 0.146314
R-squared (Adj. for d.f.) = 0.968305             Durbin-Watson statistic = 2.8699
```


Plot of LOG TACAIR.totalhrs
observed
9.5
9
8.5
8
7.5
7
6.5
7
8
9
6.5
7.5
8.5
9.5
predicted

```
                      Stepwise Selection for LOG totalhrs
===============================================================================
Selection: Forward            Maximum steps: 500            F-to-enter: 4.00
Control: Manual                    Step: 2                 F-to-remove: 4.00

R-squared:  .91951     Adjusted: .90341        MSE: 0.0636581       d.f.: 10

Variables in Model        Coeff.  F-Remove  Variables Not in Model P.Corr. F-Enter
-------------------------------------------------------------------------------
  1. LOG vmaxa           0.81513   15.5149  2. LOG wl               .1361    .1699
  3. LOG ws DIVIDE L     1.17652   43.4467  4. LOG we               .0584    .0308
```

```
                    Model fitting results for: LOG totalhrs
===============================================================================
Independent variable                 coefficient  std. error     t-value   sig.level
-------------------------------------------------------------------------------
CONSTANT                               -6.321636    1.345547     -4.6982      0.0008
LOG vmaxa                               0.815134    0.206945      3.9389      0.0029
LOG ws DIVIDE LOG wavi                  1.176524    0.178494      6.5914      0.0001
-------------------------------------------------------------------------------
R-SQ. (ADJ.) = 0.9034  SE=        0.252306  MAE=        0.176933  DurbWat=  1.817
Previously:    0.8864             0.273619              0.184449            2.196
13 observations fitted, forecast(s) computed for 9 missing val. of dep. var.
```

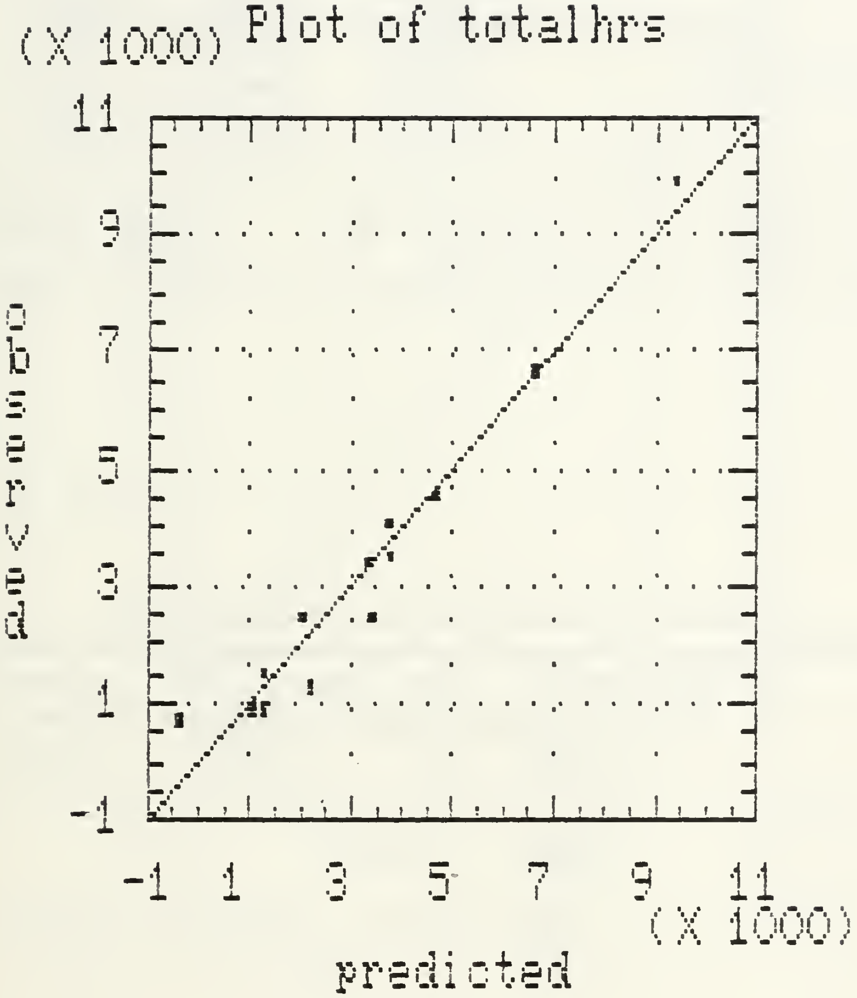
```
                   Analysis of Variance for the Full Regression
===============================================================================
Source                 Sum of Squares     DF      Mean Square       F-Ratio   P-value
-------------------------------------------------------------------------------
Model                         7.27197      2          3.63598       57.1174     .0000
Error                        0.636581     10        0.0636581
-------------------------------------------------------------------------------
Total (Corr.)                 7.90855     12

R-squared = 0.919507                              Stnd. error of est. = 0.252306
R-squared (Adj. for d.f.) = 0.903409          Durbin-Watson statistic = 1.81723
```


Plot of LOG totalhrs
observed
9.5
9
8.5
8
7.5
7
6.5
7
8
9
6.5
7.5
8.5
9.5
predicted

```
                      Stepwise Selection for totalhrs
===========================================================================
Selection: Forward            Maximum steps: 500            F-to-enter: 4.00
Control: Manual                   Step: 4                  F-to-remove: 4.00

R-squared:  .95398      Adjusted: .93097         MSE: 480629          d.f.: 8

Variables in Model          Coeff.  F-Remove  Variables Not in Model P.Corr. F-Enter
---------------------------------------------------------------------------
  1. vmaxa                 2.33585    7.4979
  2. wl                    30.9369   13.6181
  3. ws DIVIDE wavi        101.317   20.9875
  4. we                    0.14790   24.1840
```

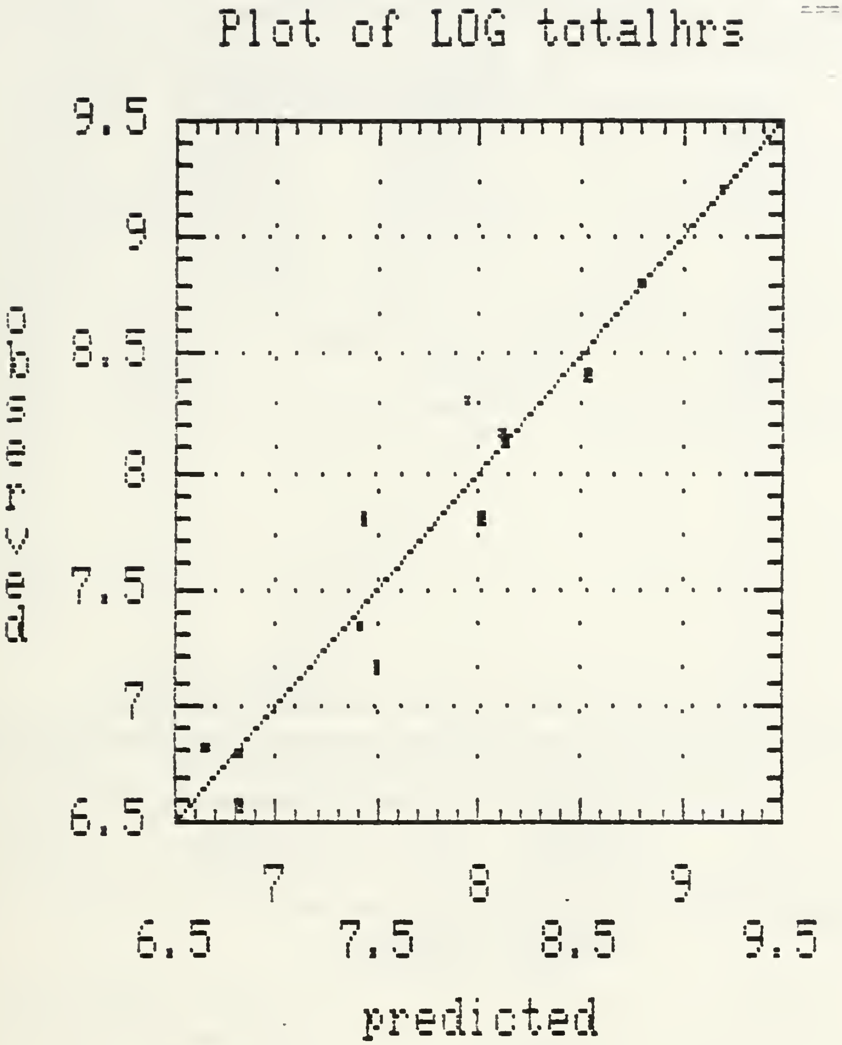
```
                     Model fitting results for: totalhrs
===========================================================================
Independent variable                  coefficient  std. error     t-value   sig.level
---------------------------------------------------------------------------
CONSTANT                             -6765.355351  983.580912     -6.8783      0.0001
vmaxa                                    2.335848    0.853053      2.7382      0.0255
wl                                      30.936863    8.383352      3.6903      0.0061
ws DIVIDE wavi                         101.316795   22.115742      4.5812      0.0018
we                                       0.147903    0.030076      4.9177      0.0012
---------------------------------------------------------------------------
R-SQ. (ADJ.) = 0.9310  SE=      693.273796  MAE=      422.562358  DurbWat=  1.256
Previously:     0.9299          698.587123            417.243790            1.346
13 observations fitted, forecast(s) computed for 9 missing val. of dep. var.
```

```
                  Analysis of Variance for the Full Regression
===========================================================================
Source                 Sum of Squares     DF     Mean Square      F-Ratio   P-value
---------------------------------------------------------------------------
Model                       79705877.      4       19926469.      41.4592     .0000
Error                        3845028.      8         480629.
---------------------------------------------------------------------------
Total (Corr.)               83550906.     12

R-squared = 0.95398                              Stnd. error of est. = 693.274
R-squared (Adj. for d.f.) = 0.93097           Durbin-Watson statistic = 1.25585
```


Plot of totalhrs
(X 1000)
11
9
7
5
3
1
-1
observed
-1
1
3
5
7
9
11
(X 1000)
predicted

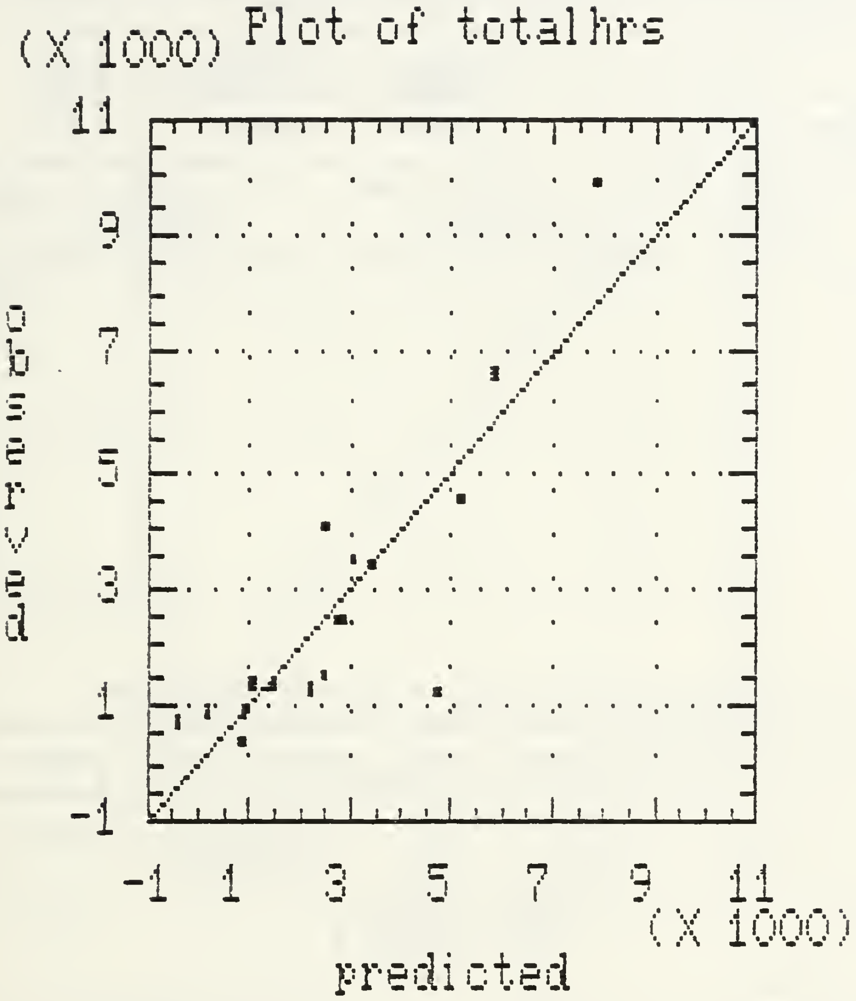
```
                        Model fitting results for: LOG totalhrs
=======================================================================================
Independent variable                   coefficient  std. error     t-value   sig.level
---------------------------------------------------------------------------------------
CONSTANT                                 -6.339618    1.689781     -3.7517      0.0072
LOG vmaxa                                 0.775971    0.234725      3.3059      0.0130
LOG wl                                    0.360059    0.393167      0.9158      0.3902
LOG ws DIVIDE LOG wavi                    1.251752    0.559645      2.2367      0.0604
LOG we                                    0.315797    0.717507      0.4401      0.6731
LOG gtow                                 -0.476118    0.483354     -0.9850      0.3574
---------------------------------------------------------------------------------------
R-SQ. (ADJ.) = 0.8829  SE=        0.277782  MAE=        0.151160  DurbWat=  2.151
Previously:    0.9034             0.252306              0.176933            1.817
13 observations fitted, forecast(s) computed for 9 missing val. of dep. var.
```

```
                      Analysis of Variance for the Full Regression
=======================================================================================
Source                    Sum of Squares     DF     Mean Square       F-Ratio   P-value
---------------------------------------------------------------------------------------
Model                            7.36841      5         1.47368       19.0983     .0006
Error                           0.540141      7       0.0771631
---------------------------------------------------------------------------------------
Total (Corr.)                    7.90855     12

R-squared = 0.931702                                  Stnd. error of est. = 0.277782
R-squared (Adj. for d.f.) = 0.882917               Durbin-Watson statistic = 2.15053
```


Plot of LOG totalhrs
observed
9.5
9
8.5
8
7.5
7
6.5
7
8
9
6.5
7.5
8.5
9.5
predicted

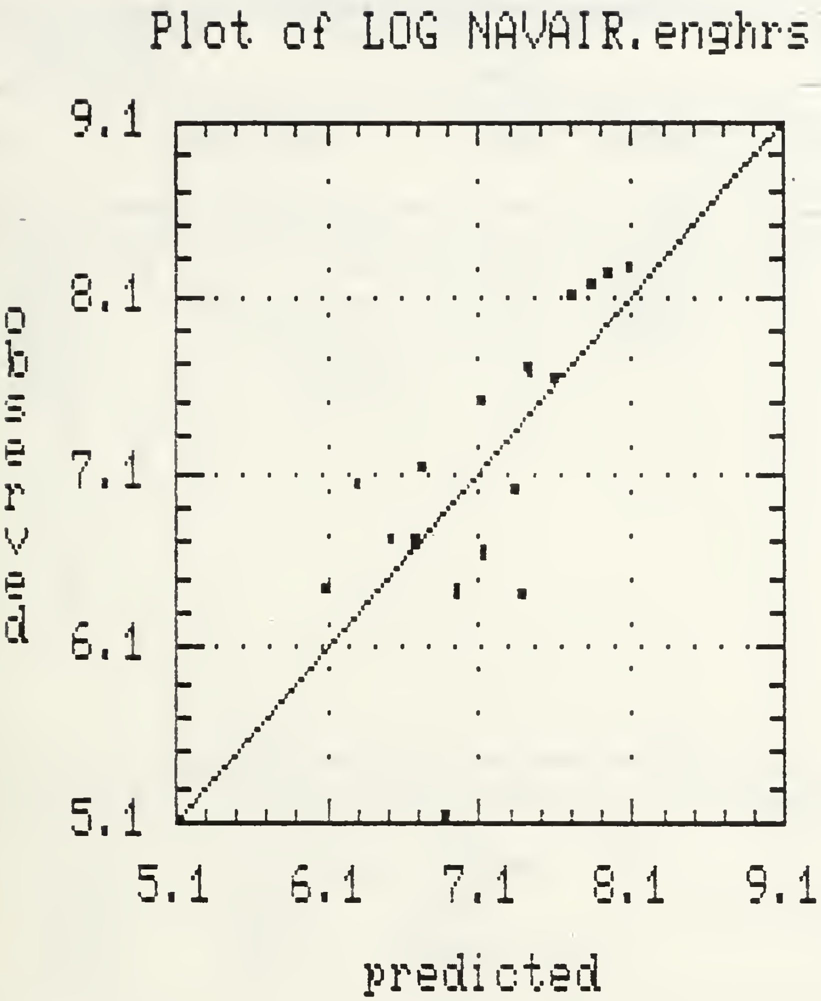
```
                       Model fitting results for: totalhrs
==================================================================================
Independent variable                coefficient  std. error      t-value   sig.level
----------------------------------------------------------------------------------
CONSTANT                           -1696.690309 1845.018323      -0.9196      0.3794
wl                                    13.233161   19.357693       0.6836      0.5097
we                                     0.268227    0.136831       1.9603      0.0784
gtow                                  -0.036665    0.062259      -0.5889      0.5690
ff                                   -29.825079    61.67896      -0.4836      0.6391
crew                                -485.906955  708.258672      -0.6861      0.5083
thrust                                  -0.0023    0.070846      -0.0325      0.9747
----------------------------------------------------------------------------------
R-SQ. (ADJ.) = 0.6070  SE=    1557.048481  MAE=      848.770571  DurbWat=  3.092
Previously:    0.0000             0.000000             0.000000              0.000
17 observations fitted, forecast(s) computed for 7 missing val. of dep. var.
```

```
                     Analysis of Variance for the Full Regression
==================================================================================
Source                 Sum of Squares     DF    Mean Square        F-Ratio   P-value
----------------------------------------------------------------------------------
Model                       74453699.      6      12408950.        5.11836     .0119
Error                       24244000.     10       2424400.
----------------------------------------------------------------------------------
Total (Corr.)               98697698.     16

R-squared = 0.754361                               Stnd. error of est. = 1557.05
R-squared (Adj. for d.f.) = 0.606978            Durbin-Watson statistic = 3.09212
```


Plot of totalhrs
(X 1000)
11
9
7
5
3
1
-1
observed
-1
1
3
5
7
9
11
(X 1000)
predicted

```
                    Model fitting results for: LOG NAVAIR.enghrs
================================================================================
Independent variable                 coefficient  std. error     t-value   sig.level
--------------------------------------------------------------------------------
CONSTANT                                0.231436    2.452182      0.0944      0.9261
LOG NAVAIR.weows                       -2.666201    1.079392     -2.4701      0.0260
LOG NAVAIR.vmaxa                        1.285233    0.385039      3.3379      0.0045
--------------------------------------------------------------------------------
R-SQ. (ADJ.) = 0.4073  SE=       0.633723  MAE=       0.441969  DurbWat=  2.332
Previously:    0.6917            0.350327             0.238806            2.077
18 observations fitted, forecast(s) computed for 6 missing val. of dep. var.
```

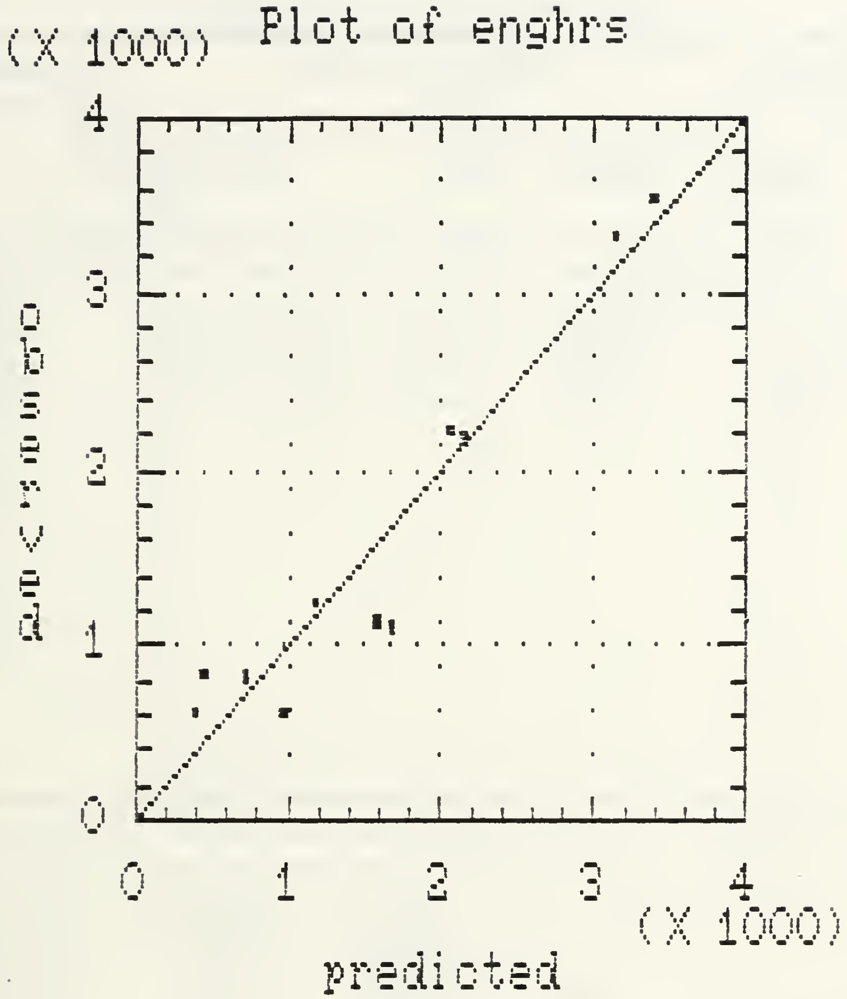
```
                    Analysis of Variance for the Full Regression
================================================================================
Source                     Sum of Squares     DF    Mean Square      F-Ratio   P-value
--------------------------------------------------------------------------------
Model                             5.49564      2        2.74782      6.84211     .0077
Error                             6.02407     15       0.401605
--------------------------------------------------------------------------------
Total (Corr.)                     11.5197     17

R-squared = 0.477064                                 Stnd. error of est. = 0.633723
R-squared (Adj. for d.f.) = 0.40734             Durbin-Watson statistic = 2.33171
```


Plot of LOG NAVAIR.enghrs
9.1
8.1
7.1
6.1
5.1
observed
5.1
6.1
7.1
8.1
9.1
predicted

```
                         Stepwise Selection for enghrs
==============================================================================
Selection: Forward             Maximum steps: 500             F-to-enter: 4.00
Control: Manual                    Step: 3                   F-to-remove: 4.00

R-squared:  .91470     Adjusted: .87814          MSE: 136185            d.f.: 7

Variables in Model         Coeff.  F-Remove  Variables Not in Model P.Corr. F-Enter
------------------------------------------------------------------------------
  1. ws                   0.23374   20.4361  2. we                    .3010    .5976
  3. gtow                -0.04050    7.9813  4. we DIVIDE ws          .0421    .0107
  6. vmaxa                1.72672   15.6414  5. gtowows               .6135   3.6217
                                             7. vmaxs                 .3278    .7226
                                             8. vcruise               .3501    .8882
```

```
                       Model fitting results for: enghrs
==============================================================================
Independent variable                coefficient  std. error     t-value  sig.level
------------------------------------------------------------------------------
CONSTANT                            -664.707451  339.993428     -1.9551     0.0915
ws                                     0.233744    0.051706      4.5206     0.0027
gtow                                    -0.0405    0.014336     -2.8251     0.0256
vmaxa                                  1.726718    0.436599      3.9549     0.0055
------------------------------------------------------------------------------
R-SQ. (ADJ.) = 0.8781  SE=      369.032815  MAE=      246.540949  DurbWat=  1.518
Previously:    0.0000           0.000000              0.000000              0.000
11 observations fitted, forecast(s) computed for 2 missing val. of dep. var.
```

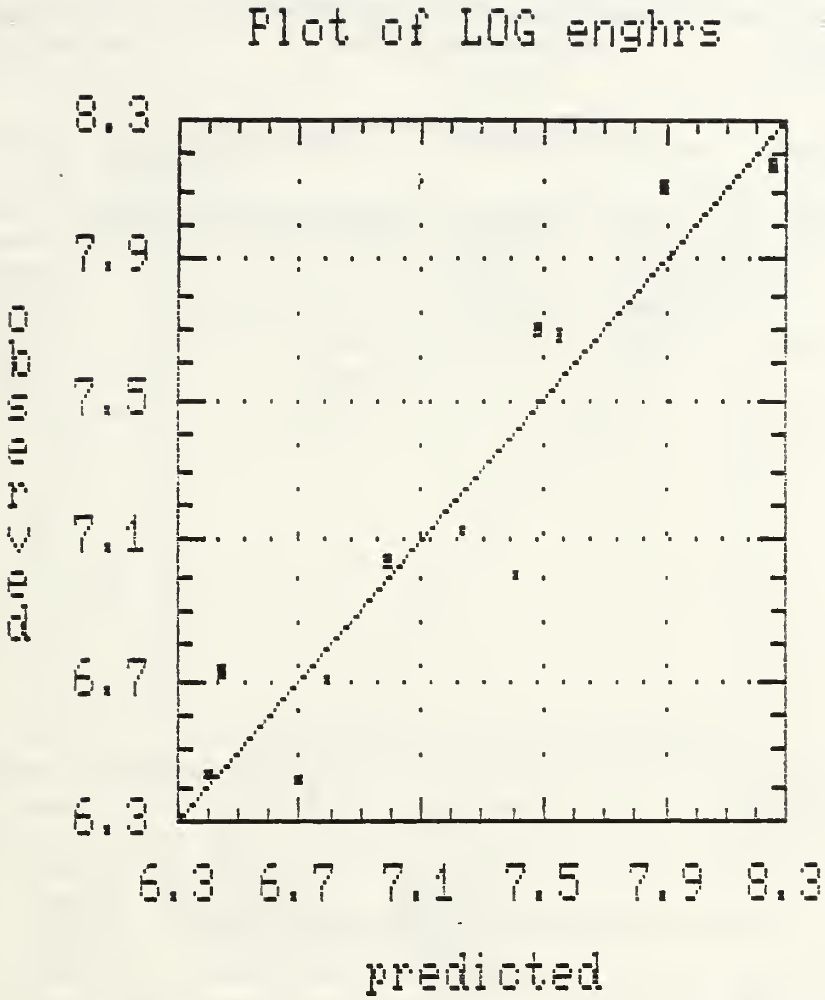
```
                  Analysis of Variance for the Full Regression
==============================================================================
Source                 Sum of Squares     DF      Mean Square       F-Ratio   P-value
------------------------------------------------------------------------------
Model                       10222599.      3         3407533.       25.0213     .0004
Error                         953297.      7          136185.
------------------------------------------------------------------------------
Total (Corr.)               11175896.     10

R-squared = 0.914701                              Stnd. error of est. = 369.033
R-squared (Adj. for d.f.) = 0.878144         Durbin-Watson statistic = 1.51797
```


Plot of enghrs
(X 1000)
4
3
2
1
0
observed
0
1
2
3
4
(X 1000)
predicted

```
                          Stepwise Selection for LOG enghrs
================================================================================
Selection: Forward            Maximum steps: 500             F-to-enter: 4.00
Control: Manual                    Step: 2                  F-to-remove: 4.00

R-squared:  .88402     Adjusted: .80669         MSE: 0.0769604        d.f.: 6

Variables in Model       Coeff.   F-Remove  Variables Not in Model P.Corr. F-Enter
--------------------------------------------------------------------------------
  1. LOG ws             0.86904    3.6446  4. LOG we                .1578    .1277
  2. LOG gtow          -0.53820    1.6251  5. LOG we/LOG ws         .1595    .1305
  3. LOG vmaxa          1.31783    9.0148  6. LOG gtowows           .1740    .1561
  8. LOG vcruise       -1.33836    2.7475  7. LOG vmaxs             .1116    .0631
```

```
                      Model fitting results for: LOG enghrs
--------------------------------------------------------------------------------
Independent variable                coefficient  std. error      t-value   sig.level
--------------------------------------------------------------------------------
CONSTANT                               4.250695     4.13965       1.0268      0.3441
LOG ws                                 0.869042    0.455213       1.9091      0.1048
LOG gtow                              -0.538204    0.422185      -1.2748      0.2495
LOG vmaxa                              1.317829    0.438916       3.0025      0.0239
LOG vcruise                           -1.338361    0.807433      -1.6576      0.1485
--------------------------------------------------------------------------------
R-SQ. (ADJ.) = 0.8067  SE=        0.277417  MAE=        0.172304  DurbWat=  2.479
Previously:    0.0000             0.000000              0.000000            0.000
11 observations fitted, forecast(s) computed for 2 missing val. of dep. var.
```

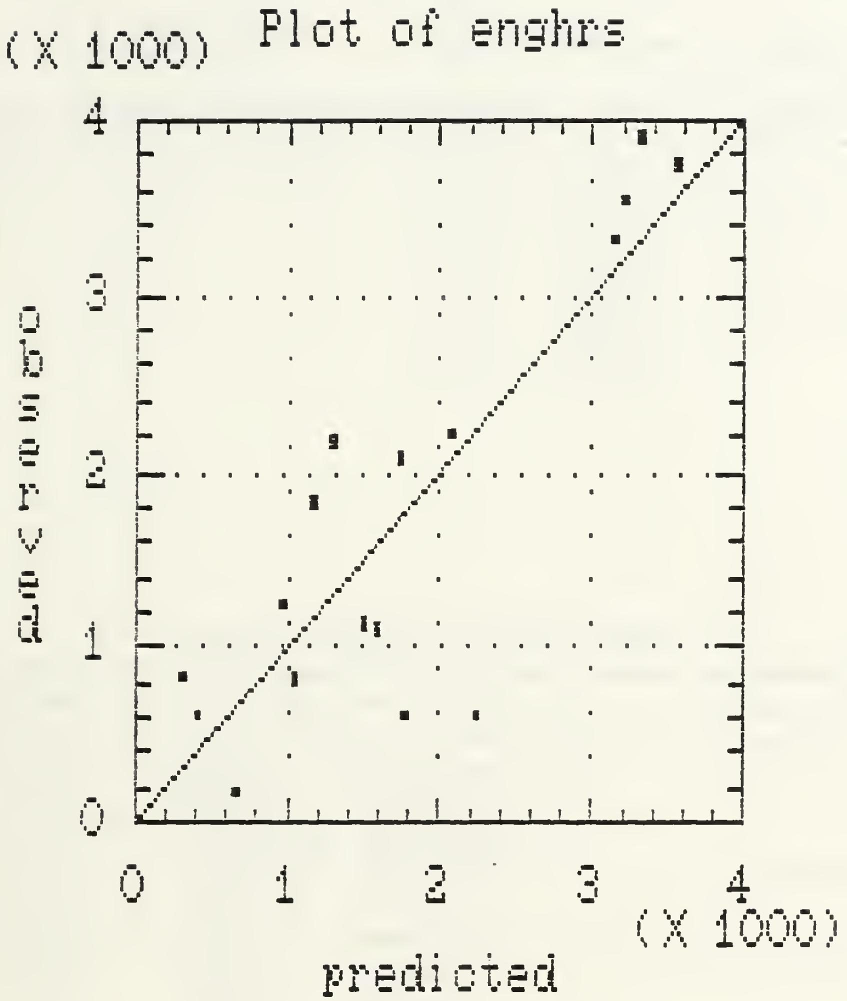
```
                   Analysis of Variance for the Full Regression
================================================================================
Source                    Sum of Squares     DF     Mean Square      F-Ratio   P-value
--------------------------------------------------------------------------------
Model                            3.51950      4        0.879874      11.4328     .0057
Error                           0.461762      6       0.0769604
--------------------------------------------------------------------------------
Total (Corr.)                    3.98126     10

R-squared = 0.884016                              Stnd. error of est. = 0.277417
R-squared (Adj. for d.f.) = 0.806693            Durbin-Watson statistic = 2.4788
```


Plot of LOG enghrs
observed
8.3
7.9
7.5
7.1
6.7
6.3
6.3
6.7
7.1
7.5
7.9
8.3
predicted

```
                         Stepwise Selection for enghrs
================================================================================
Selection: Forward            Maximum steps: 500             F-to-enter: 4.00
Control: Manual                   Step: 3                  F-to-remove: 4.00

R-squared:  .70983      Adjusted: .64287          MSE: 533350           d.f.: 13

Variables in Model          Coeff.   F-Remove  Variables Not in Model P.Corr. F-Enter
--------------------------------------------------------------------------------
  1. vmaxa                 3.20573    29.0995  2. wl                    .2895   1.0974
  6. ff                    67.1994     5.2112  3. ws DIVIDE wavi        .3199   1.3680
  8. thrust DIVIDE w      -2143.66    12.5099  4. wavu                  .0179    .0038
                                               5. gtow                  .1798    .4008
                                               7. thrust                .2148    .5805
```

```
                        Model fitting results for: enghrs
================================================================================
Independent variable                  coefficient  std. error     t-value   sig.level
--------------------------------------------------------------------------------
CONSTANT                               165.128623  571.355487      0.2887      0.7774
vmaxa                        .           3.205728     0.59427      5.3944      0.0001
ff                                      67.199366   29.437158      2.2828      0.0399
thrust DIVIDE we                     -2143.663629  606.079306     -3.5369      0.0036
--------------------------------------------------------------------------------
R-SQ. (ADJ.) = 0.6429  SE=     730.308349  MAE=      510.506300  DurbWat=  1.611
Previously:    0.0000          0.000000             0.000000              0.000
17 observations fitted, forecast(s) computed for 5 missing val. of dep. var.
```

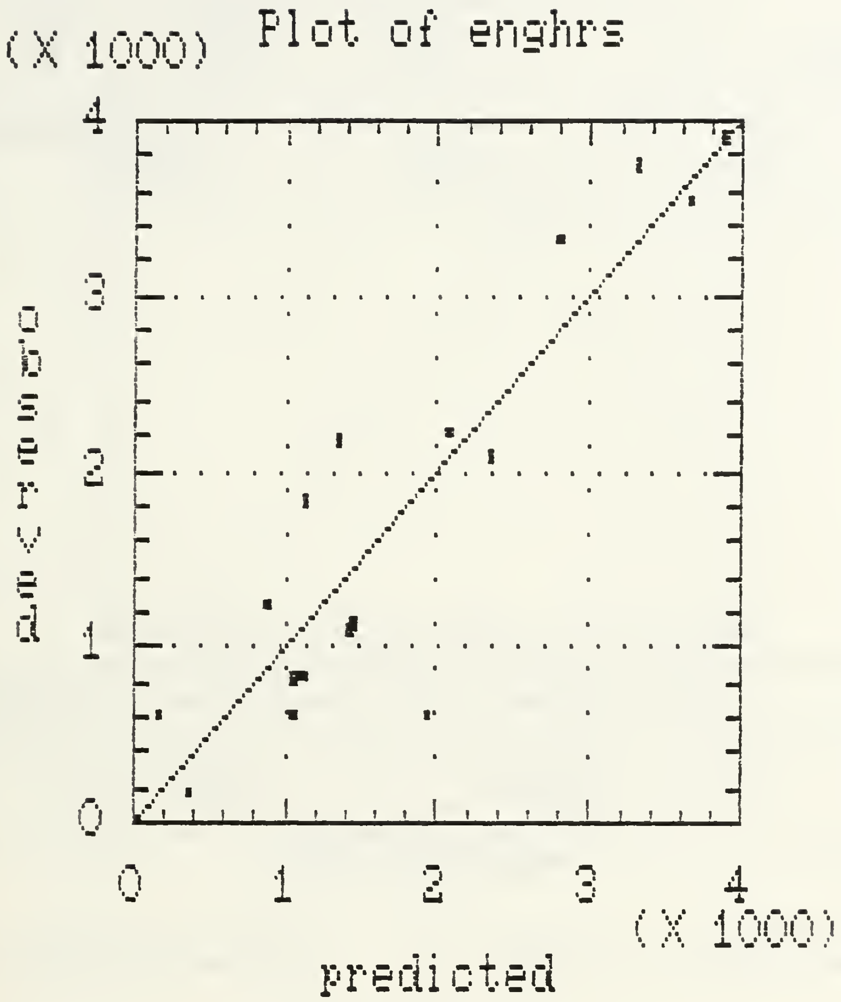
```
                   Analysis of Variance for the Full Regression
================================================================================
Source                   Sum of Squares     DF      Mean Square       F-Ratio   P-value
--------------------------------------------------------------------------------
Model                         16961072.      3         5653691.       10.6003     .0008
Error                          6933554.     13          533350.
--------------------------------------------------------------------------------
Total (Corr.)                 23894625.     16

R-squared = 0.709828                              Stnd. error of est. = 730.308
R-squared (Adj. for d.f.) = 0.642865          Durbin-Watson statistic = 1.61062
```


Plot of enghrs
(X 1000)
4
3
2
1
0
observed
0
1
2
3
4
(X 1000)
predicted

```
                         Stepwise Selection for enghrs
===============================================================================
Selection: Forward            Maximum steps: 500            F-to-enter: 4.00
Control: Manual                   Step: 3                  F-to-remove: 4.00

R-squared:  .81668      Adjusted: .67410        MSE: 486703            d.f.: 9

Variables in Model        Coeff.  F-Remove  Variables Not in Model P.Corr. F-Enter
-------------------------------------------------------------------------------
  1. vmaxa              3.31794   22.9532  8. thrust                 .1442    .1699
  2. ff                 46.0481    2.1448
  3. thrust DIVIDE w   -1295.21    3.0962
  4. wl                 9.11476    1.1207
  5. ws DIVIDE wavi     88.3058    3.7386
  6. wavu               0.64556    2.3391
  7. gtow              -0.00653    2.9320
```

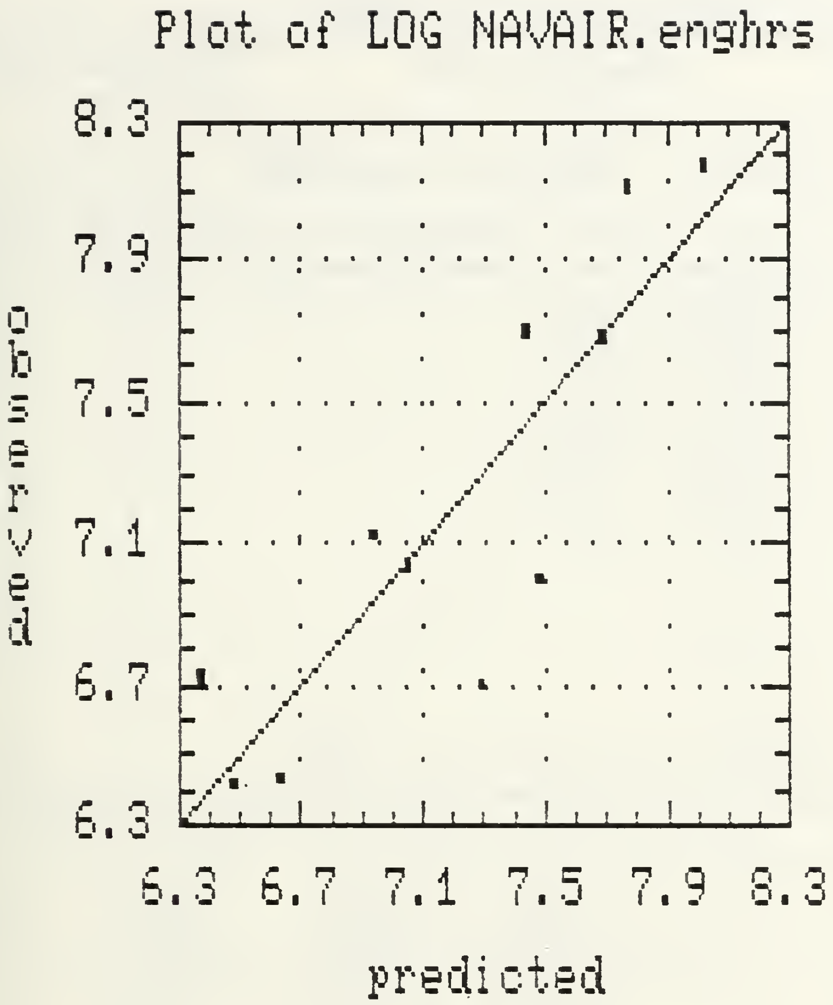
```
                        Model fitting results for: enghrs
===============================================================================
Independent variable                coefficient  std. error      t-value   sig.level
-------------------------------------------------------------------------------
CONSTANT                           -2939.879172 1539.874283      -1.9092      0.0886
vmaxa                                  3.317941    0.692544       4.7909      0.0010
ff                                    46.048133   31.442498       1.4645      0.1771
thrust DIVIDE we                   -1295.210351  736.085357      -1.7596      0.1123
wl                                     9.114757    8.610058       1.0586      0.3174
ws DIVIDE wavi                        88.305841   45.670681       1.9335      0.0852
wavu                                    0.64556    0.422098       1.5294      0.1605
gtow                                  -0.006531    0.003814      -1.7123      0.1210
-------------------------------------------------------------------------------
R-SQ. (ADJ.) = 0.6741   SE=     697.640952  MAE=      407.613940  DurbWat=  2.508
Previously:     0.0000           0.000000              0.000000               0.000
17 observations fitted, forecast(s) computed for 5 missing val. of dep. var.
```

```
                    Analysis of Variance for the Full Regression
===============================================================================
Source                 Sum of Squares     DF     Mean Square      F-Ratio   P-value
-------------------------------------------------------------------------------
Model                       19514299.      7        2787757.      5.72784     .0094
Error                        4380326.      9         486703.
-------------------------------------------------------------------------------
Total (Corr.)               23894625.     16

R-squared = 0.816682                              Stnd. error of est. = 697.641
R-squared (Adj. for d.f.) = 0.674101            Durbin-Watson statistic = 2.50797
```


Plot of enghrs
(X 1000)
observed
0
1
2
3
4
0
1
2
3
4
(X 1000)
predicted

```
                    Model fitting results for: LOG NAVAIR.enghrs
================================================================================
Independent variable                 coefficient  std. error     t-value   sig.level
--------------------------------------------------------------------------------
CONSTANT                               -6.801848    3.433679     -1.9809      0.0829
LOG NAVAIR.ws                           0.796297    0.190425      4.1817      0.0031
LOG NAVAIR.vmaxs                        1.034254    0.494547      2.0913      0.0699
--------------------------------------------------------------------------------
R-SQ. (ADJ.) = 0.6917  SE=        0.350327  MAE=       0.238806  DurbWat=  2.077
Previously:    0.9380             0.177965             0.132311             2.029
11 observations fitted, forecast(s) computed for 3 missing val. of dep. var.
```

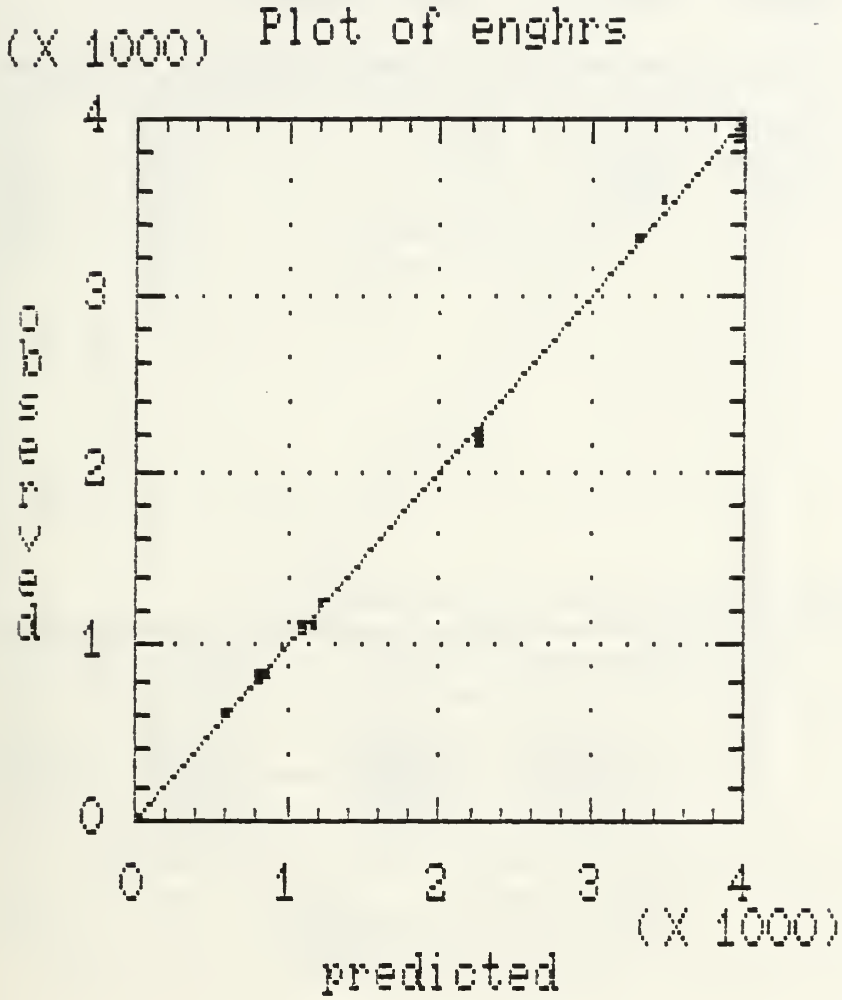
```
                    Analysis of Variance for the Full Regression
================================================================================
Source                 Sum of Squares     DF     Mean Square       F-Ratio   P-value
--------------------------------------------------------------------------------
Model                         2.99943      2         1.49972       12.2198     .0037
Error                        0.981830      8        0.122729
--------------------------------------------------------------------------------
Total (Corr.)                 3.98126     10

R-squared = 0.753387                                 Stnd. error of est. = 0.350327
R-squared (Adj. for d.f.) = 0.691734              Durbin-Watson statistic = 2.07705
```


Plot of LOG NAVAIR.enghrs
8.3
7.9
7.5
7.1
6.7
6.3
observed
6.3
6.7
7.1
7.5
7.9
8.3
predicted

```
                         Stepwise Selection for enghrs
===============================================================================
Selection: Backward            Maximum steps: 500            F-to-enter: 4.00
Control: Manual                    Step: 1                  F-to-remove: 4.00

R-squared:  .99853     Adjusted: .99266        MSE: 10641.1          d.f.: 2

Variables in Model       Coeff.  F-Remove  Variables Not in Model P.Corr. F-Enter
-------------------------------------------------------------------------------
  1. vmaxa             0.72158    9.9922  3. we DIVIDE wavi       .1213    .0149
  2. wl                7.85314   21.3107
  4. ws DIVIDE wavi    29.1986    7.1067
  5. wavu              0.36939   13.6414
  6. we                0.21610  156.0330
  7. gtow             -0.07261   98.5882
  8. ff               -18.2202    5.8794
  9. crew             -706.749   60.8837
```

```
                        Model fitting results for: enghrs
===============================================================================
Independent variable                 coefficient  std. error    t-value  sig.level
-------------------------------------------------------------------------------
CONSTANT                             -574.336252  430.901101    -1.3329     0.3141
vmaxa                                   0.721582    0.229424     3.1452     0.0880
wl                                      7.853144     1.70116     4.6163     0.0439
ws DIVIDE wavi                         29.198641   10.952899     2.6658     0.1166
wavu                                    0.369393    0.100014     3.6934     0.0661
we                                      0.216104      0.0173    12.4913     0.0063
gtow                                   -0.072606    0.007312    -9.9292     0.0100
ff                                    -18.220246    7.514298    -2.4247     0.1362
crew                                  -706.74891   90.576275    -7.8028     0.0160
-------------------------------------------------------------------------------
R-SQ. (ADJ.) = 0.9927  SE=     103.155852  MAE=      36.385286  DurbWat=  3.175
Previously:    0.9730          197.873714            100.886893            2.678
11 observations fitted, forecast(s) computed for 6 missing val. of dep. var.
```

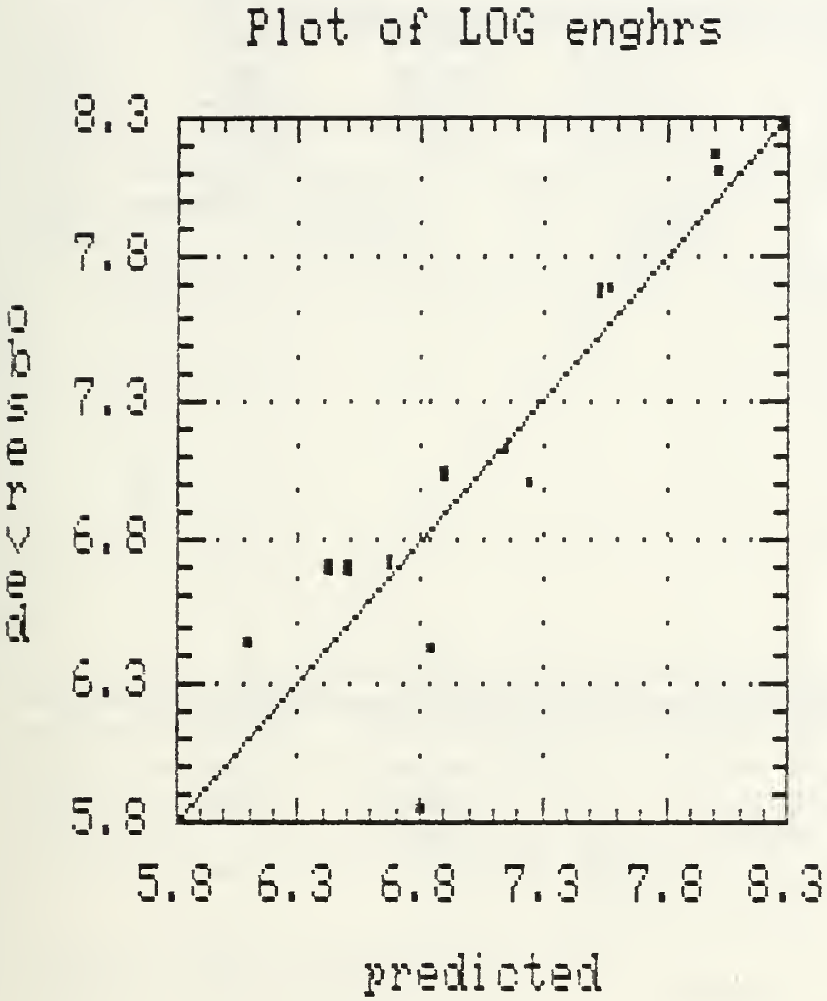
```
                  Analysis of Variance for the Full Regression
===============================================================================
Source               Sum of Squares     DF    Mean Square      F-Ratio    P-value
-------------------------------------------------------------------------------
Model                     14485948.      8       1810743.      170.165      .0059
Error                       21282.3      2        10641.1
-------------------------------------------------------------------------------
Total (Corr.)             14507230.     10

R-squared = 0.998533                          Stnd. error of est. = 103.156
R-squared (Adj. for d.f.) = 0.992665          Durbin-Watson statistic = 3.17494
```


Plot of enghrs
(X 1000)
4
3
2
1
0
observed
0
1
2
3
4
(X 1000)
predicted

```
                        Stepwise Selection for LOG enghrs
=============================================================================
Selection: Forward             Maximum steps: 500           F-to-enter: 4.00
Control: Manual                    Step: 1                 F-to-remove: 4.00

R-squared:  .79223      Adjusted: .72990        MSE: 0.148068         d.f.: 10

Variables in Model        Coeff.  F-Remove  Variables Not in Model P.Corr. F-Enter
-----------------------------------------------------------------------------
  1. LOG vmaxa          0.88684    7.2676  2. LOG wl                 .0419    .0158
  3. LOG ws/LOG wavi    2.23734   12.0092  4. LOG wavu               .1411    .1829
  6. LOG gtow          -1.51740    5.8557  5. LOG we                 .2859    .8014
                                           7. LOG crew               .3133    .9793
                                           8. LOG we/LOG wavi        .2886    .8177
```

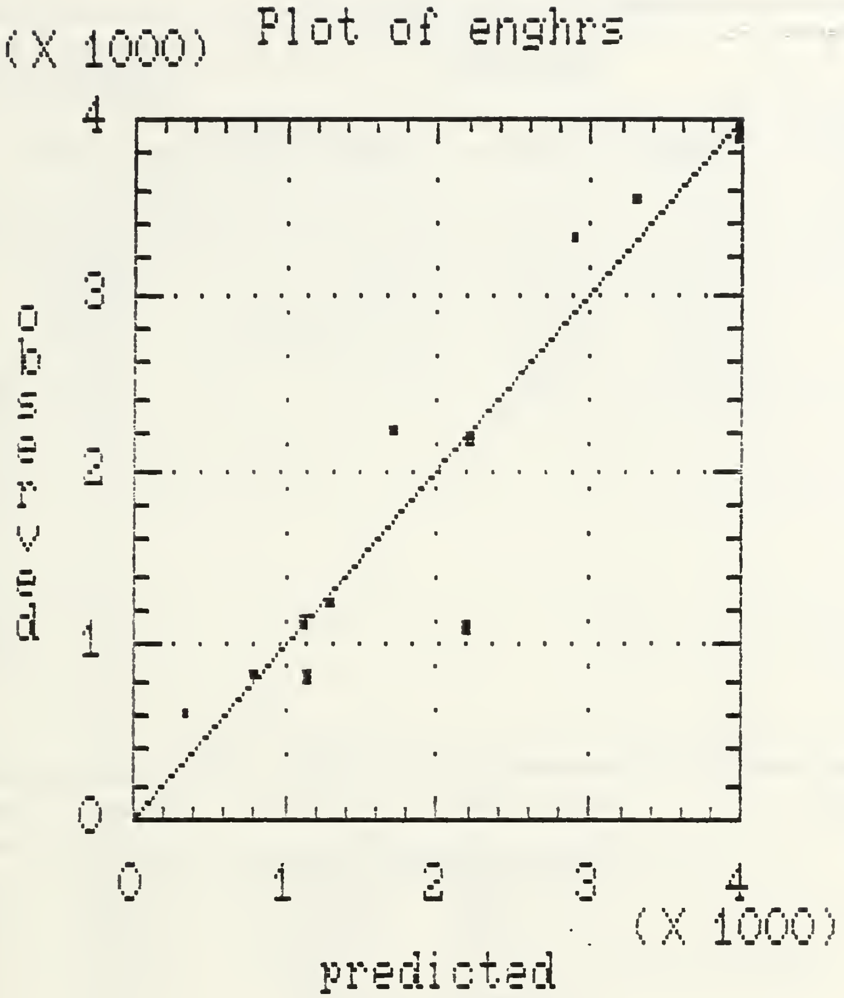
```
                       Model fitting results for: LOG enghrs
=============================================================================
Independent variable                  coefficient  std. error    t-value   sig.level
-----------------------------------------------------------------------------
CONSTANT                                 1.097246    2.630871     0.4171     0.6854
LOG vmaxa                                0.886838    0.328965     2.6958     0.0225
LOG ws/LOG wavi                          2.237343    0.645617     3.4654     0.0061
LOG gtow                                -1.517396     0.62706    -2.4199     0.0361
-----------------------------------------------------------------------------
R-SQ. (ADJ.) = 0.7299  SE=       0.384796  MAE=       0.231345  DurbWat=  2.637
Previously:    0.2515            0.773003             0.487195            2.272
14 observations fitted, forecast(s) computed for 11 missing val. of dep. var.
```

```
                     Analysis of Variance for the Full Regression
=============================================================================
Source                   Sum of Squares     DF    Mean Square      F-Ratio   P-value
-----------------------------------------------------------------------------
Model                          5.64600       3        1.88200      12.7104     .0010
Error                          1.48068      10       0.148068
-----------------------------------------------------------------------------
Total (Corr.)                  7.12669      13

R-squared = 0.792234                             Stnd. error of est. = 0.384796
R-squared (Adj. for d.f.) = 0.729904          Durbin-Watson statistic = 2.63739
```


Plot of LOG enghrs
8.3
7.8
7.3
6.8
6.3
5.8
observed
5.8
6.3
6.8
7.3
7.8
8.3
predicted

```
                          Model fitting results for: enghrs
==================================================================================
Independent variable                   coefficient  std. error      t-value   sig.level
----------------------------------------------------------------------------------
CONSTANT                              -1796.984046  675.352982      -2.6608      0.0324
vmaxa                                     1.314872    0.662056       1.9860      0.0874
ws DIVIDE wavi                           40.676451   25.293659       1.6082      0.1518
we                                        0.082504      0.0245       3.3675      0.0120
----------------------------------------------------------------------------------
R-SQ. (ADJ.) = 0.8159  SE=     516.828624  MAE=      281.317892  DurbWat=  2.817
Previously:     0.0000          0.000000             0.000000             0.000
11 observations fitted, forecast(s) computed for 6 missing val. of dep. var.
```

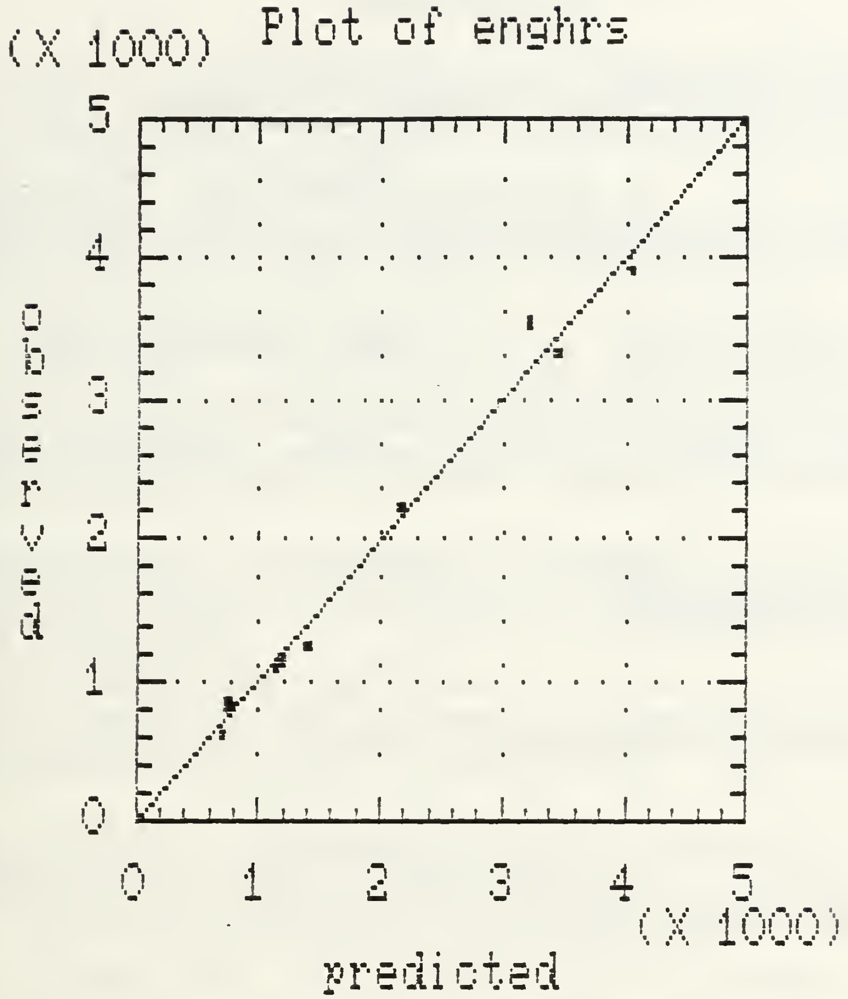
```
                     Analysis of Variance for the Full Regression
==================================================================================
Source                 Sum of Squares     DF     Mean Square         F-Ratio   P-value
----------------------------------------------------------------------------------
Model                       12637447.      3        4212482.         15.7705     .0017
Error                        1869783.      7         267112.
----------------------------------------------------------------------------------
Total (Corr.)               14507230.     10

R-squared = 0.871114                                Stnd. error of est. = 516.829
R-squared (Adj. for d.f.) = 0.815877           Durbin-Watson statistic = 2.81673
```


(X 1000)
Plot of enghrs
4
3
2
1
0
observed
0
1
2
3
4
(X 1000)
predicted

```
                      Stepwise Selection for enghrs
==============================================================================
Selection: Forward            Maximum steps: 500            F-to-enter: 4.00
Control: Manual                   Step: 3                  F-to-remove: 4.00

R-squared:  .98651     Adjusted: .97301        MSE: 39154            d.f.: 5

Variables in Model        Coeff.  F-Remove  Variables Not in Model P.Corr. F-Enter
------------------------------------------------------------------------------
  2. wl                 8.12227    6.5471  1. vmaxa                 .3713     .6396
  6. we                 0.25753  155.5007  3. we DIVIDE wavi        .0171     .0012
  7. gtow              -0.08093   55.9442  4. ws DIVIDE wavi        .1100     .0490
  8. ff                -31.1604   12.0470  5. wavu                  .5678    1.9034
  9. crew              -688.305   62.7862
```

```
                      Model fitting results for: enghrs
==============================================================================
Independent variable                coefficient  std. error     t-value   sig.level
------------------------------------------------------------------------------
CONSTANT                             427.599034  286.234759      1.4939     0.1954
wl                                     8.122269    3.174332      2.5587     0.0507
we                                      0.25753    0.020652     12.4700     0.0001
gtow                                  -0.080931     0.01082     -7.4796     0.0007
ff                                   -31.160437    8.977676     -3.4709     0.0178
crew                                -688.304888   86.865819     -7.9238     0.0005
------------------------------------------------------------------------------
R-SQ. (ADJ.) = 0.9730  SE=     197.873714  MAE=     100.886893  DurbWat=  2.678
Previously:    0.8159          516.828624           281.317892            2.817
11 observations fitted, forecast(s) computed for 6 missing val. of dep. var.
```

```
                  Analysis of Variance for the Full Regression
==============================================================================
Source                 Sum of Squares      DF     Mean Square      F-Ratio   P-value
------------------------------------------------------------------------------
Model                       14311460.       5        2862292.      73.1034     .0001
Error                         195770.       5         39154.0
------------------------------------------------------------------------------
Total (Corr.)               14507230.      10

R-squared = 0.986505                              Stnd. error of est. = 197.874
R-squared (Adj. for d.f.) = 0.973011          Durbin-Watson statistic = 2.67847
```


Plot of enghrs
(X 1000)
5
4
3
2
1
0
observed
0
1
2
3
4
5
(X 1000)
predicted

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